History of Science Library
EDITED BY PROFESSOR A. WOLF

SCIENCE AND MONISM

SCIENCE AND MONISM

by

W. P. D. WIGHTMAN
M.Sc., Ph.D.

Foreword by

SIR PERCY NUNN
M.A., D.Sc., LITT.D., LL.D.

LONDON
GEORGE ALLEN & UNWIN LTD
MUSEUM STREET

FOREWORD

In the intellectual life of our age there is nothing more striking, nor perhaps more significant, than the way in which Science and Philosophy, after a long period of estrangement, have come together again and renewed their ancient comradeship. Our philosophers hail the light which advancing science seems to throw upon some of the obscurest of their problems and our physicists make no attempt to repress their interest in the metaphysical implications of their farther-reaching hypotheses. In such an atmosphere Dr. Wightman's book should have a ready welcome. For it is an able and thorough study of one of those great ideas that have inflamed the imagination and guided the inquiries both of philosophers and of men of science since the history of thought began, and is written with a breadth of competence which not many students could achieve.

Twenty years ago an eminent philosopher-scientist, Professor Hans Driesch, then lecturing in London, recorded "the general impression that great interest in questions of the Philosophy of Nature prevails all over Great Britain —more, perhaps, than in other countries." Since that opinion was set down there have appeared not a few works wherein the interest which Professor Driesch noted has been worthily developed; and I venture to think that the book which I have the honour of commending to its public will take an important place among them.

T. P. NUNN

PREFACE

THE writing of this book was prompted by the belief that the time was ripe for a reinvestigation of the problem, as old as science itself, of the unity of nature; the problem of whether the scientific world-picture encourages us to adopt a monistic philosophy. I was faced at the outset, however, by a difficulty I had not anticipated, namely, that there exists no considerable work on monism in the English language. This fact, I felt, was a sufficient justification for placing this work, which was originally a thesis presented to the University of London for the degree of Doctor of Philosophy, before a wider public.

At the present day the accumulation of scientific knowledge is so rapid, and the esteem in which it is held so high, that its so-called "facts" are often removed from their context and used to "prove" the validity of some philosophical belief to which they have no *immediate* relevance. Thus we are confronted with a world in which a hedonistic materialism co-exists with a somewhat nebulous idealism; a world whose churches are half empty, but whose newspapers and bookstalls testify to a growing interest in religious questions. And strange to say, the partisans of all these conflicting ideals call upon the same body of knowledge—modern science—as the authority for their views. The chief cause of all this confusion of thought lies, I am convinced, in the failure of even the most eminent writers to realize the imperceptible but often profound change which has crept over the connotation of terms. The most diverse

creeds can call upon some commonly accepted theory if each presses his own interpretation upon the concepts out of which this theory is constructed. "What is the use," as Professor Whitehead has written, "of asking whether a mechanical explanation of nature is possible, if you do not know what you mean by mechanics?" Precisely so; and yet there seems to be no end to these fruitless wranglings.

The hope of the future, in my opinion, lies in a greater emphasis being placed upon the *history* of concepts. In this conviction I have devoted the First Part of this book to an attempt to show that the question as to whether science reveals monism in nature or not is utterly meaningless until it has been decided what particular *kind* of monism is being sought for. In the Second Part I have outlined the development of the unitary concepts of science down to the time when Ernst Haeckel included them in the first speculative monism based on natural science. The Third Part examines all too briefly the nature of the relevance, if any, which natural science may have to the wider problems of philosophy. The ground thus prepared, it is possible in the Fourth Part, not indeed to seek conclusions, but to indicate the *kind* of monism which the present state of science permits us to envisage. Here I have freely criticized some tendencies which I regard as subversive, in the belief that the scrutiny of the patient, if ungifted, amateur may possibly do something to clarify the general confusion of thought which follows inevitably from the picturesque but misleading manner in which scientific truth is now being garbed.

My obligations are numerous and profound. The reader need hardly be told that the whole thesis draws its main

inspiration from the works of Professor A. N. Whitehead; first "rousing me from the dogmatic slumber" of a new-fledged science graduate twelve years ago, they have guided and enriched my intellectual life ever since.

To Professor Sir Percy Nunn and Professor A. Wolf I offer my most sincere thanks: to the former for putting his name to so cordial an introduction; to the latter for his unsparing efforts to warm my heart with the love of Spinoza, and to save me from the grosser errors of the neophyte in philosophy. Moreover to him, as Editor of the Series, has fallen the task of revision of the whole text.

Dr. Ross, Provost of Oriel, very kindly read and criticized the first chapter; Professor E. T. Whittaker did a like service for the twenty-first. To them both I tender my thanks.

To my colleague, Mr. R. M'Ewan, and to my wife, are due my gratitude for constant encouragement and advice, without which my resolution might have proved unequal to the task.

In conclusion, I am glad to be able to acknowledge the generous grant sanctioned by the Senate of the University of London in aid of the expenses of publication, and the help which I received through the Advisory Service of the University.

WILLIAM P. D. WIGHTMAN

23 HOWARD PLACE, EDINBURGH

January 1934

CONTENTS

PART III

THE DATA AND CONCEPTS OF NATURAL SCIENCE

PART IV

MONISTIC TENDENCIES IN THE TWENTIETH CENTURY

PART I

THE HISTORY OF THE MONISTIC CONCEPT

CHAPTER I

THE CLASSICAL PERIOD

THE first monist was he whose voice was first raised bidding men cast off the cramping shackles of their own passions, break from the narrowing influence of tribal custom, and seek in the great world about them not the reflection of their own warring desires, affections, fears, and vengeance, but the orderly if infinitely complex process of one substance, spirit, God, or what you will. With no certainty, however, can we point to any thinker earlier than Thales of Miletos, as he in whom the Oneness of reality was so strong an intuition that he must seek for some tangible stuff upon which to fix his ideas. But if Thales is the first man in whom this conception has become explicit, we must nevertheless admit that the very civilization which gave him birth had come into being as the result of a gradual if unconscious process of correlation and generalization. If primitive man knew nothing of one substance, but only trees, animals, and spears; acknowledged no God, but only an infinity of warring spirits; so soon as improvement in the amenities of life gave him leisure for contemplation and with it the recognition of the orderly element in nature —the periodic return of night and morning, of seed-time and harvest—he must have felt the inadequacy of his soul-filled chaos, gradually, and for the most part inarticulately, replacing the multitude of souls by a small number of powerful gods. These gods, bearing in their petty iniquities

the stamp of their human origin, seem to have sufficed men when in the rise of the great Minoan and Mycenean civilizations, out of which the Greece of Thales' time grew, man cast aside his barbarism and disciplined himself in artistic creations such as have hardly ever been surpassed. Indeed, it is from an even later age, namely that of the Homeric epics, that we have the greatest knowledge of these gods. Now there is evidently no transition from the crude philosophy of the epics to the enlightened, if naïve, generalization of Thales that water is the material cause of everything. With Thales a new spirit was born, a new attitude towards the world, that attitude which we now call the scientific.

The pre-eminence of the cosmology of Thales and his contemporaries over all those that had gone before (such as those of Homer and Hesiod and the Priestly Writer of Genesis who wrote probably a little later than Thales) lies, as Professor Cornford says, "not so much in what it contains, as in what it leaves out. Cosmogony has been detached from theogony" (F. M. Cornford, *Before and After Socrates*, p. 19). In one generation the duality of the natural and the supernatural had been obliterated.

So it is easy enough to see why the history of philosophy starts with Thales. We must next try to understand why, having established nature as a closed system, his intuition led him to posit it as a unity. The reason lies, I think, in the fact that he and his contemporaries were less interested in what things *are* than in *how they originated.* Now any attempt to seek the cause of the world, which halts at the position of *more* than one generating principle, does so quite

arbitrarily; for if there be two such principles, either they must be related to a third (in which case they are not the "first beginnings"), or they could have no means of interaction one upon the other.

It is not, of course, to be supposed that Thales argued thus. Had he been bound within the limits of strict reasoning he could never have jumped to the conclusion that the primordial stuff was water; for though this choice showed a remarkably acute reading of the book of nature, yet a moment's hesitation must have convinced him of the existence of a number of facts inconsistent with it.

The internal contradiction in Thales' teaching was in fact recognized by Anaximander, who clearly was endowed with an insight into natural philosophy much in advance of his age. He saw that the primordial stuff must be unlimited and different in kind from any "existing" substance; for if water "being cold and moist" were the infinite substance, it would have destroyed its opposite "hot and dry" (fire) ere now. The "material cause" is therefore "boundless,"[1] "undifferentiated" being, from which, by the "separation out" of the opposites contained therein, proceeded "innumerable worlds." He goes further than this, and hazards the opinion that the higher animals are descended from the lower, which in turn have been formed spontaneously by the sun's action on the moist element. Nor is this a mere figment of a daring imagination, for not only did he see that man's helplessness in infancy is but a poor adaptation

[1] "ἄπειρον." Burnet takes the view that this means "spatially infinite," and not, as Paul Tannery and Teick-Müller believed, "qualitatively indeterminate." The latter view is certainly the more tempting (Burnet, *Early Greek Philosophy*, pp. 57 ff., notes).

to his environment, and that without some better adaptation he must have perished, but he thought he saw in the manner in which a shark nourishes its young an explanation of how the earliest land mammals were descended from fish and were thus able to survive. Lastly, he first enunciated the principle of inertia in the guise of a special case of the principle of sufficient reason: since the earth is equidistant from all things, there is no reason why it should move in one direction rather than another; it therefore remains where it is, needing no support. We have in Anaximander's, then, a strikingly complete monistic interpretation of the world: one substance, from which arise all things, and into which, by virtue of their mutual oppositions, they once more pass away; and no "occult" causes. At the level of his times it had but one serious fault, that the primordial substance was beyond the reach of direct apprehension; and this, to an age of thinkers who were men of science rather than metaphysicians, was a drawback.

The fault was corrected in the system of Anaximenes. Returning to the more empirical attitude of Thales he stated that though the material cause of all things is indeed infinite, yet it is not indeterminate, being none other, indeed, than air, which in the form of our soul holds us together, and likewise encompasses the whole world. This at first appears a retrograde step; but the principle of differentiation which he adds thereto is of the utmost consequence for the further development of natural philosophy, namely, that it "differs in different substances in virtue of its rarefaction and condensation." Now a single unalterable substance can be the substrate of a world of marvellous variety only by

reason of a quantitative variation of its content in a given space; and that is precisely what Anaximenes meant, for in another place he says that "when it is dilated so as to be rarer, it becomes fire, while winds on the other hand are condensed air . . . still further condensed it becomes water" (quoted by Burnet from Hippolytos). One other means of differentiation he postulates, namely, motion; but this is of less value, as he gives no explanation of where and how an infinitely extended substance can move.

Before leaving the Milesians it is perhaps desirable, in view of their status as pioneers of natural philosophy, to sum up their position. Their importance for the history of philosophy is this, namely, that they were obsessed with the *coherence* of nature, and being so, sought for something which had the greatest power to produce effects. Such a thing, which they probably called *φύσις*, afterwards came to be known as a substance. Having no knowledge of mind (for the first critique of which the world had to wait for Socrates) they fastened upon those objects of the senses which seemed to them most powerful, permanent, and pervasive; and when we consider how much of modern science is taken up with the properties and powers of air and water we can congratulate them on their insight. But the choice itself is of no consequence; it is the recognition of its possibility which is everything. It is, in fact, no exaggeration to say that in this intuition of Thales lay the germ of the modern world (*cf.* Whitehead, *Science and the Modern World*, p. 260).

While the basis of scientific monism was being worked out by the sages of Miletos, a school of philosophy was

coming into being at Samos which was to have the profoundest effect on all future systems of nature. According to a feasible if unauthenticated tradition, Pythagoras discovered that the harmonic intervals of a monochord are in the ratio of the lengths of the vibrating string. This was the birth of mathematical physics. How many other instances of the strict numerical relationships between natural phenomena Pythagoras and his followers were able to demonstrate, we cannot say; but we are told that they were certainly very few. Thus, again, one of our Fathers in science boldly leapt to a stupendous generalization from the slightest of evidence; and this is the privilege of genius, gladly granted, for it differs from the hasty conclusion of the common man, in that unlike the latter's it is usually the right conclusion. Because he recognized that in a fleeting ever-changing accumulation of objects one thing, namely, the numerical relationship, was precisely determinable and unalterable, he declared that "Things are Numbers." He has been sharply criticized for identifying material objects with numbers; but to a Greek of his day an object of consideration was either material or non-existent: yet numbers were intensely real, therefore necessarily material. Indeed, the Pythagoreans are believed to have introduced the method of representing numbers by sets of points having magnitude (*vide* Burnet, *op. cit.*, p. 90. For an alternative view that Pythagoras taught only that things are *like* numbers, *vide* Burnet, *op. cit.*, pp. 307–9). From his psychological standpoint, therefore, his statement was a perfectly natural apophthegm for the great truth he had discovered. As soon as he or his followers—we have no means of dis-

tinguishing between their several contributions to what became the doctrine of a semi-religious sect—began attributing actual numbers to specific things, they fell into nonsense, and their future history concerns us no more.

The thinker, however, who was in the direct line of development from the Milesians was not Pythagoras but Herakleitos, the monistic status of whose system is peculiarly difficult to determine. Dr. Eisler contrasts his system with that of the Eleatics as "the monism of the passage of events [*Geschehen*]" as compared with the "monism of Substance," which is satisfactory enough provided that with him we accept the "fire" of Herakleitos as being not on the same footing as the "air" of Anaximenes and the "water" of Thales. In accepting this interpretation we are supported by Schwegler, who says: "But obviously we must not understand this statement as if Heraclitus, like the Hylicists, had made fire the primitive matter or element. He who ascribes reality only to becoming itself cannot possibly collocate with this becoming an additional elementary matter as fundamental substance" (*Handbook to Hist. Phil.*, p. 21). Against this view, however, we are compelled to set the opinion of Burnet: "That the Fire of Herakleitos was something on the same level as the 'Air' of Anaximenes is clearly implied in such passages as Arist. A 3.984 a 5" (*Early Greek Phil.*, p. 145, note 1). Moreover, he goes on to show that the opposite view is based on a misinterpretation of a remark in the "Cratylus" of Plato. Herakleitos himself says: "This world . . . was ever, is now, and ever shall be an ever-living Fire." "The transformations of Fire are,

first of all, sea . . ." (quoted by Burnet, *op. cit.*, pp. 134–5). This gives no clue to the problem save that it admits that Fire is transformed into sea, whence according to another fragment it will rise again consuming the sea. Since he gives no account of the mechanism of this transformation (the "rarefaction and condensation" which, according to Diogenes Laertius, Theophrastos attributes to Herakleitos is regarded by Burnet as a mistaken view of the latter), the interpretation of Dr. Eisler seems to be the most satisfactory, namely, that there is no reality save in "Becoming," our senses deceiving us into believing that there are "things" instead of an eternal flux of a primordial fire-like stuff. Burnet very clearly shows that in the apparent permanence of a flame Herakleitos would naturally see the closest resemblance to his metaphysical views; it is only with regard to the actual status or literalness of the Fire-stuff that there is any dispute. Moreover, however we interpret the Fire-stuff, the system of Herakleitos is a monistic one, in so far as there is some one substrate, in the eternal flux and change of which we see the sole reality: "You cannot step twice into the same rivers; for fresh waters are ever flowing in upon you." Nevertheless, this is not the most original part of his system, it being only another answer to the question of the Milesians as to what was permanent in nature; but in his discovery of the necessity of "strife" we have an original contribution of the first order. We have seen that to the central problem of the Milesian monism, the differentiation of the One into the Many, Anaximander gave as his solution that the oppositions contained within the substrate are separated out, and further, that they

"make reparation and satisfaction to one another for their injustice" (Burnet, *op. cit.*, p. 52), which means merely the balance of conflicting natural forces. Now whereas Anaximander regards this conflict from the point of view of the maintenance of equilibrium, any injustice (*i.e.* encroachment) to be redressed, Herakleitos points out that it is of the very essence of becoming; and becoming is reality. "Homer was wrong in saying: 'Would that strife might perish from among gods and men!' He did not see that he was praying for the destruction of the universe; for if his prayer were heard, all things would pass away" (Burnet, *op. cit.*, p. 136). There are several other fragments to the same effect, all well worth consideration, but one other only can be cited here: "Men do not know how what is at variance agrees with itself. It is an attunement of opposite tensions, like that of the bow and the lyre." We must not read into this more than could possibly have been in the mind of Herakleitos when he propounded this apophthegm, but from our viewpoint it is pregnant with the principle which underlay the rebirth of monism in the mind of Bruno; it contains the germ of the greater part of modern physics; and from a slightly different point of view it points to the mechanism of biological evolution. When, added to this, comes the recognition of the fact that by stressing the primacy of process he has removed the duality of mover and moved, and paved the way for Lyell's *Principles of Geology*, it is hard to speak of Herakleitos save in exaggerated terms. His monistic system has gone the way of all the great, wild, all-comprehending enthusiasms of the childhood of science; but two of his three fundamental principles will still be

he inspiration of men of science when our own systems ave faded into the glories of the past.

With the system of Herakleitos we have reached a crisis n the purely monistic view of the world. Indeed, a warning iote had been sounded before the time of Herakleitos by Kenophanes; but since the germ of his thought flowered nly in the teaching of philosophers following Herakleitos, t was judged convenient to consider the latter's system first.

Xenophanes was essentially a satirist, but used the philo-ophical conceptions of his time to press his point, which vas the non-existence of any gods save the world itself. The oint is well argued, but when we come to consider the elation of "God" and the world we get less satisfaction; or, to start with, the world is both infinite and "equal very way," which presumably means spherical. This con-usion is not resolved by any of the properties of God (*e.g.* hat He did not breathe, but was sentient), which are just hose that were commonly attributed to the world. Other ragments indicate that he may have had a higher concep-ion of the world-god, but nowhere is there any indication of a polemical grounding of the "One" as a metaphysical system.

For this we must turn to Parmenides, who realized that none of his predecessors had taken the One seriously; for if the One *is*, there can be nothing else. True, the Milesians had seemingly escaped the dilemma by assuming some form of motion, and this is where Parmenides places his finger. For there can be no motion unless there is empty space in which the material substance can move; but this is the common feature of their systems, for even Anaximenes'

"condensation and rarefaction" is a virtual affirmation of empty space. To which Parmenides replies, How can we think of nothing? That which is unthinkable is non-existent. There is no empty space; and therefore no motion. The only alternative is to endow the One, as did Herakleitos, with the internal capacity for change; but this to Parmenides, as to us, if the One is conceived as corporeal, was a contradiction in terms. "Undiscerning crowds, who hold that it is and is not the same and not the same, and all things travel in opposite directions!" The One alone, then, *is*; eternal, immutable, continuous, immovable, but finite and spherical. (The last two properties were later shown—by Melissos—to be inconsistent with one another.)

The system of Parmenides is negatively as important as that of Herakleitos; for the conclusion to which it leads, namely, that the phenomenal world, depending everywhere on change and motion, is mere illusion, reveals the internal contradiction which had pervaded all Greek thought up to his time. Further progress was now possible only if philosophy either ceased to be monistic, or ceased to be materialistic. But, as Burnet points out, the non-corporeal was not conceivable (*op. cit.*, p. 180), so with the realization of the dilemma of Parmenides came, for the time, the downfall of monism. It is important to note, however, that the actual dualism into which the apparent monism of Parmenides sunders is one of the most insidious kind, namely, of "appearances" and "reality," of phenomena and "things-in-themselves," an apparition which has since sat like Dark Care behind every philosopher who has ridden forth in the quest for truth.

Melissos of Samos restated the doctrine of Parmenides, but with one modification, which is of the utmost consequence for the later development of the monistic concept. Whereas Parmenides regarded the One as spherical and consequently finite in space, Melissos held that it is infinite in space as in time; for if it is not infinite it must either lie in empty space, or be bounded by something else; but empty space is nothing, the non-existent; and if there were something else to bound the One, it would no longer be the One; consequently the One is infinite. It was by a development of this line of argument that Spinoza proved the existence of only one substance.

The discussion of the full development of the Eleatic doctrine has carried us forward in time beyond that of Empedokles and Anaxagoras, who in reply to the dilemma of Parmenides founded the first definitely pluralistic systems.

Empedokles admits the strength of Parmenides' position, but ridicules the non-existence of the phenomenal world; the majority of the things we see and touch are evidently transitory, arising from something else and into another passing away. But that which *is* neither changes nor passes away; things, then, are formed by the mixture of the "four roots" or reals, being brought together by love and separated by strife. There seems to be no doubt that he regarded these six as extended, self-subsistent substances; there can therefore be no question of monism here. In his more scientific and detailed application of evolution theory he assisted in the forging of one of the most valuable weapons of the later monistic philosophers.

Anaxagoras starts from very much the same presuppositions as Empedokles. But the substantival pluralism of the former has gone too far: he objects to the roots "being cut off with a hatchet." Instead of this he regards matter as infinitely divisible quantitatively, but not qualitatively; that is, the "seeds," however small (and they may be infinitesimal), contain all the opposites (hot, cold, etc.), but in different proportions. Of these, stirred to movement by *νοῦς*, is the world built. *Νοῦς* probably had the same status as "love" and "strife," being extended, though "finer" than any other matter. If in the qualitative inseparability of the "opposites" we are led to see a tentative return to monism, the introduction of the self-subsistent *νοῦς* marks the system as an unresolvable dualism.

There is, however, between the sterility of the early monistic systems and the rather arbitrary pluralism of Empedokles a middle path which, being unobscured by the ill-defined *νοῦς* of Anaxagoras, became the starting-point of many of the most important philosophical systems of later years, systems whose fruitfulness remains unexhausted even at the present day. This was the atomic theory, which is generally attributed to Leukippos of Miletos, though some authorities regard Demokritos as the founder and not merely the developer of the earlier views. However that may be, the underlying principle seems to be clearly that if we are to save the phenomenal world from the unsatisfactory condition of non-existence, we must shatter the Parmenidean One into a multitude of minute and indivisible fragments, thus restoring the possibility of motion. But this involves the existence of empty space which

Parmenides had declared to be impossible, because nothing cannot be thought. To Leukippos, however, this was a verbal quibble; the void certainly has no corporeality, but it is as "real" as the *Plenum*, *i.e.* the whole assemblage of material particles.

The second step taken by Leukippos was in reply to the famous demonstrations of Zeno of the contradictory nature of "an indefinitely divisible, continuous substance," namely, by the denial of infinite divisibility.

In taking this step Leukippos established nature as a substantival pluralism—the atoms being uncreated and accordingly indestructible. But his view that the phenomenal world needed for its explanation no further principle save the motion and impact of the atoms (the more or less lasting aggregations of which constituted the material objects of sense) displays the first example of what may be called "systemic monism." This doctrine, which as the basis of a materialistic philosophy is rather vaguely referred to as "mechanism," was elaborated and expounded by Demokritos, who welded the notion of "restlessness" of Herakleitos with the numerical "harmony" of the Pythagoreans. Although the later members of this sect had hinted that the numerical relations between phenomena are alone real, the numbers themselves being only linguistic "labels," it was left to the atomists to show that given the primordial indestructible motion of the atoms, then the variety of existent objects, their origin and decay, could be explained by reference to the numerical relationships, namely size, density, velocity, and orientation, of the atoms, without the assumption of any qualitative differences therein. This view, coupled with

the emphasis of strict causal necessity between all events, and the denial of any occult causes, self-regeneration of the substance, or striving towards an end, made of atomism the theory *par excellence* upon which the mighty fabric of modern physics could be reared. The great influence which this system had upon contemporary thought in an age when the status of knowledge itself was becoming the central problem, necessitated an explanation of the possibility of recognizing qualitative differences, colour, temperature, sound, and the like, in objects devoid of qualitatively differentiated parts. To meet this, Demokritos put forward two complementary views which, though well suited to meet the immediate difficulty, had later the gravest consequences alike for psychology and metaphysics; these are, first, the sharp distinction between the primary qualities of texture, motion, weight, which exist in the "things themselves," and the secondary qualities of colour, taste, sound, which exist only for the percipient; and second, the view by which our knowledge, being dependent on the secondary qualities, is only a "representation" of the real thing. This "bifurcation of nature," in Professor Whitehead's happy phrase, was necessary for Demokritos, since with his denial of any qualitative difference between the physical and mental no other theory of perception could have been consistent. Moreover, for him the bifurcation is more apparent than real, since perception is brought about, not by the movement of any intermediate medium, but by the direct impingement on the organs of sense of atoms released from the perceptual object, and in the form of "images" of the latter reacting with the attenuated "fire atoms" which

constitute the mind (*cf.* Lucretius, *On the Nature of Things*, Bk. IV, trans. by H. A. J. Munro). The mind is thus in virtually direct contact with corporeal reality, but its knowledge thereof is "obscured" by the nature of its "fire atoms."

Since atomism is of the greatest importance in the further development of our subject, it is desirable to sum up its position in a few words. To its credit it laid the foundation of that type of monism—systemic—which is perhaps destined to be the most fruitful of all. But it must be realized that the "mechanistic" monism of the atomists is monistic only by ignoring the existence of certain unresolvable dualities (*vide* Chapter XXII *infra*). Thus in asserting that the mental world is a merely "refined" complex of the material, they mark the beginning of the futile shift known as epiphenomenalism, which is content to preserve unification by stating that one of the spheres is a mere shadow or aura of the other, which alone is "real." Further, with atomism sets in the now time-honoured fallacy of regarding the concrete-abstract relationship as reversible. This was shown up by Aristotle in the particular case of the spatial relations of the atoms. He pointed out that by denying the divisibility of the atoms they deny in effect their extension, which is to deny the very quality by which material bodies are recognized. Yet it was to obviate the contradictory results of assuming the opposite that the atomists had enounced the impossibility of infinite divisibility. The dilemma is indeed unresolvable on these lines, since infinite division is a process applicable only to an abstract quality, space, and not to concrete objects. A great truth therefore lay hidden within this apparent confusion.

Before leaving the atomists it would be well to enquire a little more closely into the validity of the relationship between *plenum* and *vacuum.*

In order that there may be atoms there must be boundaries, therefore something to limit them; Leukippos asserts the former proposition while in effect denying the inference: that is, he asserts that between the atoms there is nothing. Now to the objection of Parmenides that nothing cannot be thought, later criticism has added the even more cogent one that nothing can have no reality, that is if by reality we mean activity or power to produce effects. In other words, mere absence of being cannot be the cause of limitation of being; if there exists a multiplicity of discrete "substances" there must be some other qualitatively different "substance" to limit them. This weakness of all pluralistic systems was first fully realized by Spinoza (*vide infra*, p. 75). The failure to recognize its wide applicability has been called by Professor Whitehead "the fallacy of vacuous actuality."

A worse failing in the eyes of Aristotle (and though this is of less metaphysical validity the almost universal persistence of Aristotle's point of view in man's nature is not to be lightly brushed aside) was that the ἀνάγκη (necessity, absolute predestination) left no room for final causes, value, or design. There were also deeper causes at work hastening the decline of the old philosophic order. These causes, in part political, in part sociological, in part methodological, meet in man's profound discovery of his own subjectivity; a discovery to which attention was drawn by the exaggerated challenge of Protagoras, the Sophist, "Man is the measure of

all things." The possibilities of analysis and criticism of this principle occupied the thought of three of the greatest intellects the world has ever known; but the inevitable sundering of the unity of reality resulting from the cultivation of this new standpoint debars our detailed consideration of the marvellous illumination of the thought process which Plato gave to the world, or the collection and ordering of the mighty mass of knowledge which resulted from the unparalleled labours of Aristotle. With Plato indeed the immutable world of forms and values is in some respects the high-water mark of the monistic concept as elaborated by the Greek mind,[1] but his failure to link this with the phenomenal world by any comprehensive system of physics as distinct from that based on the "Pythagoreanized" atoms precludes our giving at this point any but passing reference to his thought. In the case of Aristotle the attempt at a thoroughgoing physics was fraught with far more baneful consequences for the future of Science than was the geometrical schematism of Plato. In the former we have the sad spectacle of a great naturalist and systematist attempting to use the little understood tool of mathematical physics to erect a world-system in which all observed phenomena should be related to ends. The confusion of two concepts, *viz.* strict causation and teleology based on "fitness" and essence, drove him into the dogmatic assertion of such elementary

[1] In the cosmology outlined in the *Timaeus*, Professor Whitehead sees the beginnings of the philosophy of organism, a systemic monism about which we shall have much to say. But this was a product of Plato's old age; it was his earlier "bifurcation" that was seized upon by his contemporaries (*cf.* Whitehead, *Process and Reality*, p. 128 *et seq.*).

imbecilities as makes one doubt the possibility that they and the admirably patient and astute observations on living creatures could ever have emanated from the same intellect. With his assumption of a *primum movens* external to nature, science and philosophy fall asunder, thus to remain, with but a fleeting reunion at the hands of the Stoics, for the greater part of two thousand years.

We have seen that it was the recognition of the claims of intelligence to be considered as a thing apart from nature that drove monism into the background. It is the effort to discover a unifying concept whereby the "Ideas" of Plato could be more closely related to experience, the "form" and *primum movens* of Aristotle with matter and the world, that makes us regard the Stoics as the most fruitful thinkers of the later Greek period. It is true that throughout the period during which Theophrastos and his successor Strato of Lampsakos were the leaders of the Peripatetic School the Aristotelian dichotomy was losing ground; indeed Strato seems to have gone so far as to deny the existence of a god or spirit separate from body (Eisler, *op. cit.*, p. 17); but it was the Stoics who first discovered that paradoxically from the dark sayings of Herakleitos was most light shed upon the path of progress. The "fiery principle" of Herakleitos is reborn in the Stoic πνεῦμα; this concept, however, partakes of the hylozoic nature of the Ionian primordial substance, and also of the νοῦς of Anaxagoras. As periodically self-differentiating and self-unifying, it is Herakleitic; as self-subsistent, self-generative, it is Hylozoic; but as "thinking breath," "craftsman fire" penetrating all, in all immanent, it reminds us both of the νοῦς of Anaxa-

goras and ἐντελέχεια of Aristotle. The last-named notions, however, are more precisely realized by the Stoics in the λόγος σπερματικός, to which the πνεῦμα gives birth. The world is thus seen to be an organic whole, to be judged as such, its individual parts having no reality save as ranks in the one totality; moreover, the world is its own end, all its parts being "administered" to that end.

If we duly credit the Stoics with a bold attempt to resolve the dualism instinct in Platonism and Aristotelianism; and if we in addition recognize in their system the further refinement of such concepts as entelechy and concrete universal, which have been so fruitful in modern thought, we must nevertheless admit that little epistemological analysis shows the system as such to be full of contradictions. In the words of Professor Léon Robin, "The Stoics want to be both pantheists and monotheists, for the force immanent and diffused in the world is a single 'reason' " (Léon Robin, *Greek Thought and the Origin of the Scientific Spirit*, 1928). The shadows of the Masters were too close upon them; the human race had to be born again, free from the shackles of authority, breathing the purer air of physical science, before the concept of monism could reappear in a new and clearer light.

One last vain effort did, indeed, the ancient world put forth to reduce the multiplicity of experience to rational unity: this system, although known as Neo-Platonism, would perhaps have been hardly recognized by its great ancestor. It is with no disrespect to the lofty ideals of its greatest representative, Plotinus, nor in ignorance of the great spiritual benefits which its study may bring to the individual,

that we say that it is no more than a deeper and more detailed development of that metaphysical casuistry which insists on creating a monistic system by studied setting on one side of that inconvenient aspect of reality known as the phenomenal world. (For the opposite view, however, see Professor Lossky's most interesting remarks in *The World as an Organic Whole*, p. 83 *et seq.*) For Parmenides it was "illusion"; for Plotinus it is "emanation" from the One, which latter, however, loses nothing thereby. Phenomena are therefore only "copies" of reality, and the aim of philosophy is to free the soul from the shadow, giving it wings to soar to the absolute. But here Plotinus completely forsakes the methods of Plato; for not by enquiry, reasoning, and proof are we to separate the real from the false, but by the antithesis of reason, the "philosophic swoon," whereby the soul seeks not the absolute, but is filled with it.

CHAPTER II

THE MIDDLE AGES AND THE RENAISSANCE

DURING the twelve hundred years which separated Plotinus from Bruno the monistic concept underwent little modification. This is due, on the one hand, to the air of finality given to the search for monism by Neo-Platonism, and, on the other, to the spiritual and political triumph of Christianity, which, though monotheism was the bedrock of its faith, opposed even more than had Plotinus the real world of the spirit to the world of deception which is that of the flesh. From the teachings of Jesus of Nazareth we gather no authority for the harsh dualism between flesh and spirit, which came largely as a result of the leadership of the movement having fallen upon Paul. These teachings propound no philosophical system, and the attempt to weld them to that of Plato by the early Fathers, to Neo-Platonism by J. S. Erigena, to Aristotelianism by Aquinas following Averroës, was foredoomed to failure, and led to dogmatism and tyranny. It is, however, probably due to the Church's frequent return to Neo-Platonism that, when at last the revolt against authority broke out, its form was closely related to that system. We find the first clearly expressed return to this in the pantheistic views of Erigena, who, owing much of his doctrine to his own translation and study of the works then ascribed to Dionysius the Areopagite (Eisler, *loc. cit.*, p. 24; Ueberweg, *History of Philosophy*, trans. by G. S. Morris, 1885, Vol. I, p. 358), went a step

further than had Plotinus in reconciling the immanence of God with His transcendence. God, the uncreated creator, is yet one in essence with His creatures; for this reason all things which have proceeded from Him strive to return to Him; He is the beginning and the end. The mechanism of this proceeding of things out of God was not in the form of "emanations," but by the hypostasis of ideas to the rank of substances—*Universalia ante rem*—which makes of this doctrine a Christianized Platonism. Although giving a more rational explanation of the origin of the world than that held by the orthodox Church of his day, it savoured too much of pantheism; indeed, in regarding God as that from which all had been abstracted, that is, the most perfect universal, it amounts precisely to logical pantheism. Naturally this enlightened thinker fell under the official disapproval; but his work was to be the basis of most of the thought and disputation of the Middle Ages. On the one hand, he is the precursor of Scholasticism (that is, the learned study, correlation, and criticism of the works of the Fathers) and realism (the development of his principle of the reality of the class concept above that of individual things, which are real only in so far as they partake of the reality of the class); on the other hand, we cannot but see in his "logical" pantheism a sign of the undying influence of non-Christian philosophy, which was to break out on all sides and overwhelm in time the narrow cosmology of the Church. For more than three centuries, however, after Erigena's death (877?), with but a few isolated exceptions, the *pseudo*-Aristotelianism which the Church had embraced was to hold undisputed sway. In this doctrine creator and created,

mover and moved are sundered; enquiry into the causes of natural phenomena are looked upon with suspicion; science is comatose, philosophy in servitude. But when Scholasticism reached its climax in the teaching of Albertus Magnus and Thomas Aquinas, the recently introduced physical works of Aristotle and the commentary thereon by Averroës gave an impulse towards harmonizing revealed doctrine with the results of natural enquiry. Indeed, the alchemistical studies of Albert and the leanings towards Platonism of Thomas indicate the acceptance of a much broader basis of religious observance in the leaders of Christendom than could have been tolerated but a little while before. Nevertheless, there is in the works of neither any return to Neo-Platonism so thoroughgoing as that of Erigena. Before their death, however, was born Meister Eckhart, who once more brought the pantheistic element in Platonism to the fore. He reaffirms the parity of God's immanence and transcendence—transcendence in His self-revelation as that from which the world has proceeded, immanence in His Godhead, namely, that which is no individual thing but is the ground of all, that in which all opposites are resolved, in which being and becoming are one. In his assertion that the prototypes of things are in God, without whom (that is, except in respect of whom) they are nothing, Eckhart has created the loftiest form of mediaeval realism; in his notion of the love of God for Himself in all things, he anticipates Spinoza.

In Eckhart's system we have a speculative monism of a high order. He has carried the notion of unity of God and the world as far as the temper of the age would permit;

indeed further, for in 1327 he was arraigned before the Inquisition at Cologne, and went through the usual process of partial recantation and appeal, dying before the publication of the bull condemning the greater part of his doctrine to the censure and opprobrium of all good churchmen. The broadening of the concept of Godhead by Eckhart anticipates those freer flights of the human spirit characteristic of the Renaissance; indeed, although he died before the time conventionally regarded as the close of the Middle Ages, his message shows that the spirit of the Renaissance is already stirring. Yet, though he identifies nature and God, it is as it were from the side of God; before this unification could be given precision and clarity, objective evidence of the unity of nature was requisite; and it was just here that the new spirit found most scope for its exuberant energy.

If Eckhart hailed the birth of the Renaissance, it was left to William of Occam to give the death-blow to the philosophy of the Middle Ages. With his celebrated "razor"—the categorical denunciation of the multiplication of hypotheses—he cut the roots of Scholasticism so that the tree rapidly withered and fell into ruin. This principle, which belonged far more to the seventeenth century ("*Hypotheses non fingo*") than to the Renaissance, with its "spirits," "forces," and "natural magic," was of the utmost importance, not only for ridding theology of a useless and tottering superstructure of false philosophy, but as giving a shrewd hint as to the only mode of seeking truth in whatsoever guise.

The emphasis has frequently been ill-placed on the part played by the Renaissance in the birth of modern science.

In all save the one essential—that of curiosity and free enquiry—the Renaissance spirit is the antithesis of modern scientific method. In the revolt against the logical formalism which alone of Aristotle's system had the whole-hearted support of the Church, it was not to Demokritos, Euclid, Archimedes, or Hipparchus that men turned, but to Plato. This had the happiest results for literature and art, but for science the case was otherwise. It is true that the study of mathematics was again taken up with an enthusiasm and a thoroughness that it had not known for a thousand years, and progress was of course immensely accelerated by the introduction of Arabic numerals; in this department the spirit of Plato had triumphed to the lasting benefit of the world. But looking through the steady stream of Plato's works, which poured from that great elixir of the New Learning, the printing press, for signs of an interest and guidance in the study of nature itself, the eager naturalists must have looked in vain. Thus disappointed by the master they must have turned, we may believe, to his followers, the Neo-Platonists, and to those works of the Middle Ages which possessed their stamp; for how otherwise could the science of the period, in observation so varied, in description (*e.g.* anatomy) so precise and minute, in spirit so antagonistic to authority, have nevertheless plunged back into a refined barbarism, where all entities, though manifestations of one spirit, were yet possessed of hidden powers, subject to spells and incantations, and thus to be controlled, instead of by such patient correlation as had led Hipparchus to discover precession, or by rigid deduction and verification such as had placed in Archimedes' hands the key to mechanics?

We must perhaps regard the Renaissance as the childhood of the modern world, characterized by the shortcomings as well as the advantages of that fascinating period; having thrown off one control (*i.e.* the Church) it had not the patience to try each new guide in the fire of its own newly won freedom of judgment, but must needs be borne along on the billows of a new enthusiasm. It was an age of false starts and hasty conclusions. Astronomy became heliocentric, but failed to rid itself of the Platonically inspired epicycles; physics had rid itself of the Aristotelian *primum movens* as principle of all motion only to fall into the worse error of endowing individual entities with souls; chemistry dethroned the philosophers' stone only to replace it by Archeus and Tartarus.

But strange as it may seem, though the science of the Renaissance lacked any sort of correlation, its philosophy was predominantly monistic. A desire for a greater precision in the grounding of a monistic system is evidenced by the controversy between the Averröists and Alexandrists (followers of Alexander of Aphrodisias, a Greek commentator on Aristotle, who was gradually gaining favour over Averroës) concerning the immortality of the soul. The latter regarded the individual soul as immortal in its character of "emanation" from the Divine intellect; the former regarded only the world-soul as immortal.

In the doctrine of Nicolas of Cusa, however, we have the first complete restatement of the pantheistic position, which appearing from time to time during the previous millennium came at last to fulness with Meister Eckhart. There is nothing fundamentally new in Nicolas's teaching:

the doctrine of the trinity is maintained, the complete dependence of individuals on God is stressed. Two important concepts emerge from his writings, however, namely that "God is at the same time the greatest and the smallest, the centre and the periphery" and "Things are 'contractions' of the All which, each from its particular orientation, they mirror" (I quote from Eisler's short account, *loc. cit.*, p. 27). All knowledge is for him but a copy of reality to which it approaches as it were asymptotically.

The widespread if not almost universal tendencies towards monism characteristic of the Renaissance reached a climax and achieved immortality in the writings and martyrdom of Giordano Bruno, to whose system, if so heterogeneous a mass of doctrine may be so termed, it will be necessary to give more detailed notice than that which has been accorded to his forerunners.

In the philosophy of Bruno the concept of nature plays for the first time the principal rôle; for although God is the infinite, perfect object of knowledge and love, yet God and nature are so indissolubly one, that in seeking to know nature we are drawing near to God. But nature is to be studied at first hand on the hillside over Nola, whence may be seen the great Vesuvius; in the stars and other celestial bodies whose harmony is to be found in themselves, and not impressed upon them as a merely subjective geometrical form. Here is cast off once and for all the dead-weight of authority, which was content to regard the works of Aristotle, and these interpreted, moreover, in a narrow ecclesiastical spirit, as the *Summa Naturae*, beyond which God did not intend man to seek. Nevertheless, much as he

inveighed against their *authority*, a consideration of his views on the foundation of knowledge will show how much he is held within the confines of the Scholastic and Aristotelian concepts. Thus the origin and process of the world is determined by three causes. First the *intellectus universalis*, that is, the world-soul which as architectonic principle brings about evolution from within outwards; this corresponds to the "efficient cause" of the Scholastics. But for the operation of this cause there must be a "formal cause," the *idea ante rem*, which as it were contains the pattern of the former's action; this Bruno calls the "ideal reason" of the *intellectus*. Lastly, the ceaseless and joyous activity of nature is occasioned by its striving towards perfection; here we have the Aristotelian "final cause." Neither can he free himself entirely from the Aristotelian dichotomy of matter and form, potentiality and actuality; for in elevating the *intellectus* to the rank of the principle of all forms, which by its operation brings all possible forms into existence in matter, he is coming perilously near to a complete substantival dualism; indeed, he presses this dualism further than did Aristotle, whom he censures for admitting the likelihood of the annihilation of the soul with the death of the body; on the contrary, says Bruno, "body nor soul need fear death, for both matter and form are *constant abiding principles*." In his theory of world-process he is therefore no innovator, but has cast the demiurge of Plato and the One of Plotinus into a single mould with the teleology and formative principle of Aristotle; and this by correlation with the formal categories of causation of the Scholastics.

When we turn to his philosophy of nature itself, however,

it is quite otherwise. Following Plotinus he recognized that the very possibility of distinguishing between matter and form implies their relationship to a common ground or substrate; and this, he argues, is borne out by the constant natural change of one thing into another, which could not come about otherwise. Pushing the argument still further, he borrows from Nicolas of Cusa the belief that in the ultimate all contrariety is coincident, illustrating it by the identity of a straight line and an infinitely large circle. He seems thus to save himself from the dualism referred to above; his "constant abiding principles" being evidently more of the nature of what Spinoza later termed "attributes," the "substance" of the latter being represented by the indeterminate, all-comprising unity which Bruno identifies with God.

Armed with this inspired faith in the unity of all reality, Bruno allowed not the lack of evidence to deter him from seeing uniformity everywhere in nature. By a naïve conversion of the principle of sufficient reason—"As the philosopher must not believe what cannot be demonstrated by evidence, so neither must he foolishly despise or find fault with what cannot be disproved by reason"—his imagination leapt to the realization of truths which the more rigorous but infinitely slower methods of modern science took centuries to confirm. His greatest feat of this kind was, after accepting with a greater alacrity and enthusiasm than did most of his contemporaries the Copernican hypothesis of a heliocentric orbit for the earth, to leap to the conclusion that the planets are but worlds like ours, that the fixed stars are other suns with planetary

systems like the solar; and that suns, stars, and planets are composed of the same matter as our earth. These contentions, which appeared to his contemporaries as wild heresies, have been largely confirmed by the telescope and spectroscope; but his emphatic assertion of the existence of *inhabited* worlds, though in his day neither more nor less probable than his other views, has so far not only received no confirmation, but its possibility has even been called in question. It is interesting to note that he takes the trouble to give a sound reason for the non-observation of other planetary systems, namely, that the *reflected* light of the planets would be immeasurably dim in comparison with the direct light of the stars, a fact which Tycho Brahe does not seem to have taken into account when rejecting the Copernican system on the ground of the non-observation of the phases of Venus.

The influence of science on the contemporary philosophy is well illustrated in Bruno's case; for so long as he is ordering the *heavens* his results are sound, even if arrived at by some measure of special pleading; and astronomy, of all the sciences studied in the Renaissance, was most free from the cruder enthusiasms of Neo-Platonism. It is true that astrology flourished as at no other time. (It may be noted in passing that it was an interest in astrology which turned Newton's thoughts to geometry. Brewster, *Memoirs of Sir I. Newton*, p. 21.) But the leading minds were able to keep the two subjects apart; and this was due to the mathematical basis of astronomy from which there was no escape. In no other branch of science had the quantitative aspect been stressed, so that when Bruno "explained"

magnetism and gravitation as the movement of bodies towards the objects of their desires, saw literally sermons in stones, souls in trees, and in all things the reflection of everything else, he was allowing his own high trust in mathematics as the guide to knowledge to be relegated to one department of nature. In the study of living things, particularly, his confused eclecticism landed him in very obvious absurdities. Dominated by the Aristotelian dogmas that every organism is striving to become actually what it is potentially, and that its organs are so fashioned as best to fit it for this task, he decided that man must be inferior to the animals, for deliberation is a substitute for the more naturally perfect instinct, which in animals leads to the right action immediately. Further, his Neo-Platonic leanings drove him into the assertion that "all things are becoming everything else"; the very stones are endowed with intelligence and motive power to fit them for their task; so that if we push his reasoning far enough we must conclude that man is also inferior to *them*. His exaggerated notions of the "perfection" of animals are founded on such fancies as that the porcupine stores up spines on its body and hurls them with unerring accuracy at its enemies!

No notice of his natural studies would be complete without reference to his clear recognition of the relativity of knowledge. This was brought home to him at an early date, when, after having long thought the lower slopes of Vesuvius, as seen from the hillside above Nola, to be a gloomy and barren waste, he found on journeying thither that not only were they in fact as a garden of olives and flowers, but that it was now his fair Mount Cicala that appeared bare and

forbidding. He applied this principle with remarkable foresight to the study of geology, explaining thereby that what we call "mountains" are in reality but the jagged summits of huge mountain systems, namely, the continental masses; moreover, even these do not materially alter the sphericity of the earth, which to a distant being would appear no rougher than a ball of pumice does to us.

It would not have been consonant with his great admiration for mathematics to have left no theory of the mechanism of natural occurrences. To this end he revived the atoms of Leukippos and Demokritos, but in a form which would have been hardly recognizable to their originators. Not only did Bruno insist that all the atoms are identical, but he endowed them with an intrinsic vitality whereby they might pass, but not fortuitously, from organism to organism, from star to star. This strange mixture of mechanism and teleology, which anticipates the monadology of Leibniz, was constructed by Bruno as a counterblast against the Aristotelianism which was dominating the study of nature. But again the shadow of that universal influence lay so much upon him, that denying the possibility of empty space he filled up the void between the atoms with an impalpable ether which, itself unmoved, might transmit the movement of light and heat.

There is but one more point to mention before we attempt to assess the contributions of Bruno to the determination of the concept of monism, but it is of great importance in its bearing on the thought of his time. It is hardly an exaggeration to say that the whole intellectual standpoint of the Middle Ages was determined in large measure by the Aristo-

telian cosmology of a geocentric *finite* universe; the earth, and Man its crowning glory, was not only the pivot of the heavens, but was as it were in communication therewith; hence the parochialism of mediaeval theology. This it was instinctive in Bruno to combat. As we have seen, he felt that the earth was but one of a cloud of worlds, and a subordinate in its own small system; man likewise was a not very perfect animal. And argument strengthened instinct, argument from his peculiar principle of sufficient reason, namely that since we know of no boundary, therefore no boundary exists; the universe therefore is infinite, beyond comprehension, except in so far as the greatest coincides with the least, and the universe is mirrored by every atom. But this feeling of insignificance, this regarding of man as a part of the infinite process of nature, is no pessimism; it is, as Socrates recognized, the beginning of wisdom.

Bruno stands out for us, then, rather as a seer and a rebel than as a profound and acute philosopher. In his most virulent attacks on Aristotle he hardly avoids either falling into the errors, or on the other hand wielding the weapons of his opponent. Like Copernicus and Paracelsus he arrived at anticipations of modern science rather because he "felt them" than that he had any great store of evidence. For the history of monism he is of paramount importance, in that he fervently preached belief in the unity underlying the diversity of natural phenomena, a diversity which had lain hidden until the insatiable curiosity of such forerunners as Roger Bacon and Leonardo da Vinci had laid it bare. His physical account of this unity contains much nonsense mixed with happy guesses and acute observation. Of any

metaphysical system of his we can hardly speak; in his atomism, relativity, and doctrine of coincidence of contraries he is clearly an eclectic; and in his constant raking up of great names of the past in alleged support of his views, his eclecticism is enthusiastic rather than discriminating.

The monistic naturalism of Bruno had a remarkable counterpart in the mysticism of Jakob Böhme, who stands as a connecting-link between the later Scholastics, such as Meister Eckhart, and the typical modern German philosophy. Böhme saw in nature the opposition or contrariety without which nothing can fully manifest itself. God is both One and All; but the One must be an emptiness, having neither joy nor wisdom, except in so far as it is self-differentiated, self-externalized in the All. Indeed, it is the very essence of spirit to be aware of this self-distinction. Likewise the Will of God is the basis of all-becoming, and conversely without "becoming" the activity of will is inconceivable.

We see here a revival of that monism of process at which Herakleitos first darkly hinted; but in Böhme's thought it has been, as it were, crystallized in Deity.

During the lifetime of Bruno and Böhme the Renaissance drew to a close. As men delved deeper into the literature of Greece they found beyond the dangerous vagueness of Neo-Platonism that more valuable legacy of the Greeks, namely the ordering of natural phenomena according to quantitative laws. And by a fortunate chance, which altered the whole course of history, this rediscovery of the spirit of Pythagoras came at a time when Europe, sickened by a millennium of futile striving to develop all knowledge on the basis of its ill-conceived pattern of deity, was anxious

and ready to rest its feet upon "the solid ground of nature." Within a few years of the birth of that wonderful seventeenth century were swept away the last mists of "occult principles" and world souls. Quantitative relations were the only exact knowledge; to every change in matter must correspond a cause in other matter. The Aristotelian matter and form remain as the ultimate entities, but with Galileo's postulating of the principle of inertia, form is no longer the mover but motion itself.

We must turn now to a more systematic consideration of the various components of this new movement, with special regard to the manner in which they reacted on the philosophical concept of monism.

CHAPTER III

THE BIRTH OF MODERN SCIENCE AND PHILOSOPHY

"For it is a thing more probable, that he that knoweth well the natures of weight, of colour, of pliant and fragile in respect of the hammer, of volatile and fixed in respect of the fire, and the rest, may superinduce upon some metal the nature and form of gold by such mechanique as longeth to the production of the natures afore rehearsed, than that some grains of the medicine projected should in a few moments of time turn a sea of quicksilver or other material into gold" (Francis Bacon, *The Advancement of Learning*, World's Classics edn., p. 109).

These words of Francis Bacon sum up the new attitude towards natural knowledge which characterized the seventeenth century. By patient observation of facts over a wide but carefully defined field, by "the discovery of forms," and by the "invention of causes"—in a word, by inductive experimental enquiry—more accurate and orderly knowledge will be gained in a few years than in as many centuries by means of the so-called methods which Bacon was at so great pains to overthrow.

It has been the fashion (following Whewell) to dethrone Bacon from his ancient glory as the founder of modern methodology and the pioneer of modern philosophy, on the ground that his method, being diffuse and even vague, was of far less value to the men of science of his time than

the deductive method which they themselves created. We may readily admit that the giants of this period, namely Kepler, Galileo, and Newton, worked on almost purely deductive lines; but it is important to note that it was just those branches of science, namely chemistry, geology, and biology, which being necessarily based on a wealth of varied observations cannot reach the stage of deductive treatment until hypotheses have been suggested by inductive enquiry, that were with one exception almost at a standstill at this time. The exception is physiology; and no one who has read William Harvey's *Anatomical Disquisition on the Motion of the Heart and Blood* can for one moment deny that it was only as a result of the correlation of the data derived from numerous and varied dissections that the great physiologist arrived at his brilliant discovery. Any criticism which Bacon merits should be based, rather, on his depreciation of the power of deduction to establish the tentative discoveries of any inductive process, and this depreciation was almost inevitable in one whose principal claim to a hearing by his contemporaries was based on a detailed laying bare of the sterility of the existing dialectic. Conjoined with the failure to recognize the power of deduction rightly applied was his underestimation of the human factor in discovery. He utterly failed to realize that a trained logician may be a very unconvincing advocate, and a methodologist a barren discoverer; which illustrates what we have already urged, namely, that any great advance in science or philosophy must largely be the result of an apparently baseless intuition, a snatching at the garment of truth by the faint light of but a few guiding facts. While Bacon in noble periods was

proclaiming to the world his possession of the one weapon which should wrest from Nature her closest secrets, Galileo's telescope was creating a new heaven, his mathematics and manipulative skill were rebuilding the earth.

But if Bacon could not create discoverers, a careful study of his works will at least give to minds no less profound but working in other fields an insight into the rationale of scientific discovery. Without Bacon there would nevertheless have been Newton, but it is less certain that there would have been a Locke. And here lies the explanation of what may have seemed a needless digression, namely, that in the words of Ueberweg "he thus became the founder—not, indeed, of the empirical method of natural investigation, but of the empirical line of modern philosophers" (Ueberweg, *op. cit.*, p. 33)—a fact which if granted makes his claim to a place in our discussion unquestioned, despite the empty and arrogant gibe of Hegel: "So is he [*Bacon*] in effect the special leader and representative of what in England has been called Philosophy, and beyond which Englishmen have not yet quite advanced. . . ."

One final word, and we shall close our account of Bacon. While wisely rejecting all the uncritical theosophism of the Renaissance science, he yet reminds us that he is not without leanings towards monism: "And therefore the speculation was excellent in Parmenides and Plato, although but a speculation in them, that all things by scale did ascend to unity. So then always that knowledge is worthiest which is charged with least multiplicity, which appeareth to be metaphysic; as that which considereth the simple forms or differences of things, which are few in number, and

the degrees and co-ordinations whereof make all this variety" (Bacon, *op. cit.*, p. 104).

While Bacon was reviving and extending the method of induction, Descartes was showing up the cardinal error in all the mediaeval deductive enquiries, namely, that since the syllogism could not of itself yield more than was put into it, only by the operation of the mind on "clear and distinct" ideas can a true as well as consistent system be constructed. Doubting everything, he realized that the very consciousness of his power to doubt gave him the one solid ground from which to reason; namely, that he, at any rate, exists. But this is a proof only of his momentary existence; to prove that he *persists*, which the senses lead him to suppose, he had to establish a further principle, namely, the existence of God. His proofs are three in number; and though no single one can be regarded as rigorous, they lend support to each other. The existence of God once accepted, he proceeded to still all his doubts by the simple expedient of refusing to believe that God could permit his "clear and distinct ideas" to be in fact false. But the independent existence of the world of nature (which includes himself) is, next to that of his own momentary consciousness, the strongest of his intuitions; it therefore in truth exists.

Two substances, matter and thought, therefore exist. But matter, when all sense qualities, which are subjective, have been abstracted from it, remains merely as space or extension. Extension and thought are, then, the two existent substances, and all things else but "modes" of these two substances. In his re-definition of the category of substance,

which for the Scholastics was merely the "support of accidents," he fashions the basis of much of the succeeding philosophy of the seventeenth century. For him substance is unambiguously asserted to be that "which so exists that it needs nothing else in order to its existence" (quoted by Ueberweg, *op. cit.*, Vol. II, p. 51). That this definition could not in all strictness be applied to either extension or thought was fully realized by Descartes, who added that one substance alone needed nothing else to explain its existence, namely, God. It is curious that having made this inevitable inference from his own definitions and arguments, he, as it were, turned his back upon substantival monism and proceeded to develop the relations of extension and thought as those of "incomplete substances," a fact made even stranger by his introduction of the term "attribute" to connote something more lasting than mere mode or quality —something, that is, which constitutes the "nature and essence" of the substance.

The reason for this failure to achieve logical thoroughness may be due to his desire to keep on good terms with the Church, which had shown scant sympathy with the naturalistic pantheism of Bruno. It is equally likely, however, that his genius for mathematics, and his equally ardent, if less enlightened, enthusiasm for the new science of dynamics, which Galileo had lately founded, turned his interests in the direction of the philosophy of nature rather than that of metaphysics. With great thoroughness of intention and no little ingenuity of detail he sought to demonstrate the possibility of constructing the material universe out of the rigorously ordered impacts of moving masses.

In his discovery of the common ground of algebra and geometry he obtained a startling verification of the Pythagorean doctrine, for now the movements of bodies could be completely described by means of relations between numbers, namely, the distances from three mutually perpendicular axes; in other words, matter and motion were reduced to numerical relations of space—his "extended substance." On the importance of this discovery it would be superfluous to enlarge.

When he formulated the mechanical principles, upon which his construction of the universe depended, he showed himself to have thrown off the preoccupation with Aristotelian physics less successfully than had Galileo. Overlooking the latter's illuminating principle of inertia and experimentally demonstrated concept of acceleration, he based all action on collision, whence it followed that for him momentum, or as he called it "quantity of motion," is the determining factor, whose conservation he "proved" from the assumption that from God's attribute of invariability follows the invariability of the sum of His effects—the sort of lapse into mediaevalism which readily explains Newton's impatience with the *Principia Philosophiae.*

To the philosophy of living nature Descartes gave a strongly mechanistic bias which contributed greatly to the remarkable progress made in this subject then hardly recognized as a branch of natural science. Harvey's admirable demonstration of the purely mechanical principles underlying the action of the heart he hailed as a triumphant vindication of his view that organisms are automata regulated by the same laws as inert matter. But here again he

failed to achieve logical consistency, for he had somehow or other to account for the association of extension and thought in one organism—man. With considerable anatomical acumen, namely, because it is the only important organ in the brain which is simple and not duplicated, he chose the pineal body in the brain as the one point of contact between soul and body—a shift of metaphysical artificiality and of psychological inaccuracy, since later work has shown that psychic processes may continue after its extirpation (Ueberweg, *op. cit.*, Vol. II, p. 53, sub-note). Moreover, the externality of the association of body and mind led to the foundation of psychological "interaction," a doctrine which brought to a head the dualism latent in the system in which two "incomplete substances" played the leading part. The glaring inconsistency of uniting at all an unextended entity, soul, with an extended one, body, was clearly shown up by Gassendi (Ueberweg, *op. cit.*, Vol. II, p. 50; sub-note, p. 53). Either the place of union is extended, or it is a mathematical point; if extended, then the soul is also, and unextended thinking substance a myth; but no more can it be a mathematical point, for such, from the point of view of extended substance, is pure abstraction, and cannot serve as the part from which the extended brain, and thence the body, can be directed by physical means.

The bold plan of Descartes to reduce the variety of the phenomenal world to unity ended in this: that men's bodies being extended must be subject to the same laws as other extended objects; that is, all final causes and innate powers being rigorously excluded, they must be machines. And if

machines, either they will have souls, possessing power to direct but not to move them, or they will not; if they have, then the means of their association leads inevitably to contradiction, and if they have not, then thought is impossible to them. But *Cogito ergo sum*—that is, my existence, hence all other existence in which I believe—is inferred from my thinking. The contradiction is radical; the system, as a system, untenable.

The value of the Cartesian thought for our study is twofold: positively, in that his attempt to reduce the physical world to unity met with a large measure of success; and negatively, in that the final failure demonstrates once and for all the impossibility of trying to explain interaction between mind and body in the sense in which they are usually conceived, i.e. as having no common attribute. Such an interaction is an implicit contradiction in terms.

As has already been indicated, it was the very harshness of the dualism into which the Cartesian system sundered that determined the flow of pilosophical speculation among his followers. The resolution of this dualism had to proceed along one of three lines. The interaction of mind and body might be regarded as a *pseudo*-phenomenon, the real exchange of influence being referred to a common ground. This is essentially the view taken by Geulincx, who argued that since I know not *how* I act, I cannot be the cause of the action, but only the "occasion" whereby the efficient cause acts. The efficient cause is God, who maintains a miraculous harmony between my soul (will) and my body, whereby His Will is achieved by my action. This theory

is no true explanation, since it introduces an unverifiable third agent.

The second line of approach was that adopted by Hobbes. With commendable thoroughness he carried the Cartesian "mechanization" of nature to its logical conclusion. Why should man be an exception to the otherwise universal phenomenon? What we are pleased to call "thought" is but the response in a highly organized machine to the continuously changing but always rigidly determined flux of events. Matter alone exists, or rather bodies, for of general abstract material substance divorced from individuals there is no evidence. Hobbes is thus the founder of modern materialistic monism; but unfortunately for the consistency of his metaphysics he was an admitted theist, which, since God for him must be material, ill agreed with his insistence on the entire absence of freedom of choice.

The third possibility was to seize firmly what Descartes had touched but let fall, namely, the full implication of his definition of substance, which carries with it a denial of the "substantiality" of extension and thought. The first step in this direction had been taken by Geulincx; the completion of it was implicit in the system of Malebranche, and became explicit in the unqualified monism of Spinoza.

For Malebranche all causation between matter and matter, matter and mind is contradiction. There is but one Cause, namely, God. So far there is little advance on the teaching of Geulincx, but Malebranche realized that here was no solution of the problem of *knowledge*. Now we know bodies only through ideas. And, as has been already shown, these can come to us neither from bodies, nor from souls, nor even

from God. In other words, the ideas are not in us at all, but we know them in God. All ideas of bodies are therefore "intelligible extension," neither in body nor mind, but, as it were, the archetype of the material world. But since the intuition of extension expresses the essence of all minds, there must be a universal reason. Intelligible extension is the object of this reason. Malebranche sums up his system in the words, "Let us abide in this conviction, namely, that God is the intelligible world or place of minds, as the material world is of bodies"; and again, "God is not in the world but the world is in God." The ideas of individual things are therefore "limitations" of the idea of God, our desires for things mere "determinations" of our love for God, and we ourselves "participations" of the divine Being.

There is in this the whole of the "theological" basis of Spinoza's monism; but the "Christian Spinoza," as Cousin called Malebranche, in order to dissociate himself from the "atheistical" conclusions of Spinoza, distinguished sharply between "intelligible extension," which is God, and actual extension, which is but a limitation of the intelligible. By reviving the notion of attribute, Spinoza removed this last vestige of duality from the Cartesian Metaphysics, thus constructing a system which was not only the first to take account of the Cartesian recognition of the two disparate realms of extension and thought, but must remain the pattern of every future monistic system.

CHAPTER IV

SPINOZA

THE concluding words of the last chapter may have given the impression that Spinoza merely pressed the occasionalistic doctrine of Malebranche a little further than the orthodox convictions of that theologian could have permitted him to do. Nothing is further from the case. It is unlikely that Spinoza was at all influenced by Malebranche. But it was an age of synthesis, partly as a result of the enormous accumulation of knowledge during the previous two centuries, and partly as the inevitable consequence of the glaring contradiction left by the Cartesian analysis. Nothing was less unexpected than that these two great thinkers should have come to similar conclusions along similar general lines of approach. But when the differences in the intellectual and moral backgrounds of the two men are duly weighed, we shall be compelled to read into Spinoza far more than at first strikes the eye, as a result of which we must conclude that although the opposition in their doctrines is perhaps not as fundamental as the learned Catholic sought to make his colleagues believe, yet it will be only a very superficial view of Spinoza which can see in his system but the logical completion of occasionalism.

On the other hand, it has been an established custom in many learned quarters to accept Leibniz's hasty dictum that "Spinoza did nothing but cultivate certain seeds of Descartes' philosophy." There can be no doubt that Des-

cartes influenced Spinoza enormously; for not only was the former the leading philosopher of the age, but to him must go the credit of being the first clearly to formulate the problems of modern philosophy. The latter fact is particularly significant; for it stands to reason that anyone who attempts a solution of those problems which Descartes revealed may be said to "cultivate certain seeds" of his philosophy; Leibniz no less than Spinoza. As Professor Roth has recently shown (Léon Roth, *Spinoza, Descartes, and Maimonides*, Oxford University Press, 1924), the whole tradition, outlook, and method of the two thinkers were poles apart. Whereas Descartes was brought up in the orthodox Scholastic tradition, Spinoza was a child of the synagogue; while Descartes' interests were mainly in natural science and practical affairs, Spinoza sought only the way of virtue, his scientific digressions being merely the necessary consequence of living in a century when to be out of sympathy with science was to be left stranded apart from the main current of intellectual progress. And lastly, the method of Descartes is synthetic, his argument proceeding from "I" to the universe; Spinoza, on the other hand, leapt intuitively to the idea of his synthesis, "*Deus sive natura*," the working out of which proceeded analytically down to individual things. These, however, they, with most of the many great figures of this great century, had in common, namely, a profound distruct of tradition and authority, and a never-failing trust in the eternal value of mathematical truth and demonstration. One thing only, apart from the first clear statement of the problem, did Spinoza owe to Descartes, and to this in his zeal for the contro-

version of the traditional view does Professor Roth give perhaps a little less than its due, namely, the apprehension of the component parts or modes of reality under various attributes. Descartes' definition of "pre-eminent attribute" of a substance as that "which constitutes its nature and essence" (quoted by Ueberweg, *op. cit.*, Vol. II, p. 52) differs but little from Spinoza's "By attribute I understand that which the intellect perceives of substance as constituting its essence" (Spinoza, *Ethics*, trans. by Hale White, revised by Amelia Stirling, 2nd edn., p. 1).

The remaining sources of Spinoza's philosophy are still under dispute by scholars; but Professor Roth has, I believe, made out an unanswerable case for the influence of the great Jewish thinker, Maimonides, who, as he points out, stood in the same relation to the Arabian theologians as Spinoza did to Descartes; indeed, the parallelism of the development of Spinoza's views with that of the teaching of Maimonides is far more striking than the superficial resemblance of the Spinozistic to the Cartesian method. There can be little doubt, also, that his monistic tendencies were strengthened by those of Neo-Platonism, whether by direct study of the originals or indirectly through the Cabbalists.

It may seem from the above very brief discussion of the sources from which Spinoza drew most that he was a mere eclectic, who dressed the discoveries of earlier times in language more appropriate to a scientific age; and in a sense this is true; the sense, that is, which has already been hinted at, namely, that the monism of Spinoza is the monism of monisms. The One of Spinoza is a dogmatic,

an irreducible One, like that of Parmenides; it follows therefore that all the fruitful conceptions cultivated by monists of the past are likely to reappear in Spinoza's philosophy. Monism of some kind is in a sense the tacitly assumed goal of all philosophy; it is also the beginning. Dualism and pluralism are in general the results of the criticism of the existing monism; thus Eleaticism was followed by atomism, as the Milesians had been followed by Pythagoras and Empedokles, and as the monism of Spinoza was to be followed by the pluralism of Leibniz. Monism is, as it were, constantly turning back into itself. Into the monism of Spinoza flowed all the monisms of the ancient world; but with this difference, that whereas they, starting with experience, sought to reduce it to a principle of unity, the keynote of Spinozism is the "search for the most perfect being" (*ens perfectissimum*), and this is that which "exists of itself"; has, itself uncaused, the most power to engender effects; is the very essence of uniformity, without which no idea of cause or law could exist. This is God.

It is significant that in neither of the works which contain his system (the *Short Treatise* and the *Ethics*) does Spinoza open his argument by reference to knowledge of himself or of the external world. In each case his first step is to clarify the concept of God by the positing of certain definitions and axioms; the next is to prove the existence of God. We are at once at grips with infinity, that is, the whole of reality; and this, with the intuition of the poet or the seer, Spinoza knows to be One. The demonstration by way of the geometrical method is a demonstration only in the sense of a "setting forth"; much of the best of his thought is

expressed in scholia and long appendices. This point is important for our thesis, which is to show how the progress of science exhibits a *nisus* towards monism, the monism which Spinoza felt but could certainly not prove, and for which his knowledge of science could have provided but little evidence. It is important also as showing how completely different was Spinoza's attack on the problem from that of the naturalistic Bruno or the mechanistic Descartes.

I have given a hint as to my attitude towards the inner nature of Spinoza's system, and have endeavoured to show that it is only by actually divesting oneself of those superficial first impressions, inevitably derived from his difficult exposition and peculiar use of common terms, that one may justly appreciate the clarity, the loftiness, the comprehensiveness of his ideas; may glimpse, however dimly, the realm of the eternal verities, which was seen by Plato alone before him, and perhaps by none since.

We shall now turn to a more systematic summary of his argument, or rather of those portions which have a bearing on our problem. Now, as has already been pointed out, Spinoza's purpose was the finding of a way of life, that is, the founding of a system of morals based on scientific grounds. Our interest is restricted to the latter half of the enquiry only; but since in my view the system of Spinoza contains, as it were, the "prolegomena to every future monistic system," I shall devote a considerable amount of time and space to a thorough investigation of these.

In the Preface to the *De Intellectus Emendatione* occurs a passage which Schopenhauer has made famous, towards

the end of which occur the words: "But love for an object which is eternal and infinite feeds the mind with joy alone, and a joy which is free from all sorrow. This, then, is something greatly to be desired and to be sought after with all our strength" (Hale White's translation, p. 5). This passage sounds the keynote of Spinoza's philosophy. It is a search for eternal good, it is therefore an ethic; it presupposes but *one* such object, it is therefore a monistic philosophy. A preliminary sketch of this search and of the general character of the results formed the remainder of the work from which the above quotation was drawn. The work is not complete, but is of importance in showing that the apparently unfounded dogmatism of the *Ethics* had a background of intellectual and moral struggle, wherein the concepts taken for granted in the later work were subjected to searching examination.

The results of this preliminary investigation were set forth in the *Short Treatise on God, Man, and His Well-Being.* But although the style is immature, the terminology not free from inconsistencies, nor the results from contradictions, the general plan of his final system is here clearly in evidence. The atmosphere of a true science of morals is here as in the earlier work, but the method is inverted. Here is no preliminary search, but almost the first words of the book are "That God exists." From the "proof" of God's existence he passes to His nature, which he summarizes in four propositions, namely: (1) That there is no finite substance. (2) That there are not two like substances. (3) That one substance cannot produce another. (4) That in the infinite understanding of God there is no other sub-

stance than that which is *formaliter* in nature. We shall not here discuss these propositions, as the general reasoning upon which they are based appears more clearly and rigorously in the *Ethics*; but it is immediately evident that they contain implicitly the doctrine of substantival monism, that is, the substantial identity of God, the infinite Being and what He is *formaliter* in nature. Spinoza next develops in somewhat careless phraseology (using, for instance, the term "substance" as equivalent to "attribute") the doctrine that the most perfect being must possess infinite attributes that two only of these attributes (extension and thought) are known to us; that all else is reducible to these two irreducibles, which, however, are not independently real (existence not being of their essence), but are rather the aspects under which the real is revealed to us. Two other characteristics of God are demonstrated which are of fundamental importance. First, that God cannot do other than He does and that all things follow with rigorous necessity, there being no chance, no "freedom" in the sense of arbitrary and independent choice. Lastly, God as *Causa sui* has a twofold reality. As *natura naturans* He corresponds to the Aristotelian "unmoved mover"; as *natura naturata* to the "moved." But the former is immanent in the latter.

The second part of the *Short Treatise* is "On Man." With the detailed study of the passions we have nothing to do but in the Preface it is laid down that man's body is only a mode of extension, his thought a mode of thought. Morals therefore are no special study pertaining to man alone, but presuppose a knowledge of nature. In other words, man being but one of the innumerable modes of the one sub-

stance—*deus sive natura*—the study of his behaviour is merely a branch of natural science. Which explains why Spinoza, who was primarily a moralist, holds the central position in our study of the monistic tendencies of natural science.

Little addition was ever made by Spinoza to the statement of his system set forth above. But between the putting together of the youthful ideas which were afterwards published (quite unintended by the author, we may believe) as the *Short Treatise*, and the writing of the *Ethics*, his thought had matured, his preoccupation with the Scholastic categories and the Cartesian mechanics completely cast aside, and his acquaintance with the mathematical and physical principles of the age perfected. The *Ethics*, therefore, for anyone who has gained an insight into the general import of his message, and is able to appreciate in its true light the geometrical form of its composition, stands out as one of the clearest, fullest, and loftiest of the great classics of human letters.

A word is necessary concerning this "geometrical method." This was not unknown before Spinoza's day, but Spinoza himself adopted it, not because he believed that a "proof" set forth in this manner was necessarily more rigorous than in the ordinary language of reasoning (in fact, he wrote a "geometrical demonstration" of Descartes' *Principia* in spite of having rejected the conclusions reached in that work), but because he wished to divest his argument of all personal bias or colouring, to set it forth with what he believed to be the absolutely impersonal objectification of Euclid's geometry. It is important to distinguish between

his geometrical method of exposition and the high esteem in which he held the subject-matter of geometry as a science; on this latter point we shall have more to say later (*cf.* also Roth, *Spinoza*, pp. 36–7).

We may now take up the detailed study of the *Ethics*, wringing from it, by the aid of his correspondence, a more thorough understanding of the basis and structure of his monism than was possible from the *Short Treatise.*

We may approach the *Ethics* by a few short quotations from the appendix to the First Part "On God": "Man is born ignorant of the causes of things, and he has a desire, of which he is conscious, to seek that which is profitable to him. From this it follows, firstly, that he thinks himself free, because he is conscious of his wishes and appetites, whilst at the same time he is ignorant of the causes by which he is led to wish and desire, not dreaming what they are; and, secondly, it follows that man does everything for an end, namely, for that which is profitable to him, which is what he seeks. Hence it happens that he attempts to discover merely the final causes of that which has happened . . ." (*Ethics*, p. 39). He then illustrates this by reference to the existence of things which are useful to us—"The sun for giving light"—"These, too, being evidently discovered and not created by man, hence he has a cause for believing that some other person exists who has prepared them for man's use" (*op. cit.*, p. 39). But it is common experience that injurious and useless things exist which were usually explained on the supposition that the gods exacted vengeance from sinful men, or when this explanation broke down in view of calamities occurring to the unjust and the just indis-

criminately, it was concluded that "the judgments of the gods far surpass our comprehension; and this opinion alone would have been sufficient to keep the human race in darkness to all eternity, if mathematics, which does not deal with ends but with the essences and properties of forms, had not placed before us another rule of truth" (*op. cit.*, p. 41).

What are we to conclude from all this? Clearly, that we must divest ourselves of our own petty desires and purposes, for things exist neither for us nor for any other end—"Nature has set no end before herself, and all final causes are nothing but human fictions." "All things are begotten by a certain eternal necessity of nature and in absolute perfection." The anthropocentric view of deity (as for Xenophanes two thousand years before him) is for Spinoza an empty sham founded on ignorance. What is the remedy? The study of mathematics and all those branches of science which deal with the "essence," "power," and "form" of bodies.

So far there is no hint of substantival monism in the argument; but in denying the freedom of man to act according to his whim, and asserting instead that man is merely a part of the uniform plan of nature, he has prepared the ground for the crucial step, namely, the insistence on the existence of one substance only. This step has, in fact, already been taken by Spinoza in the first fourteen propositions of the *Ethics*, and to this we must now turn.

It is imperative that we first ascertain precisely what Spinoza meant by the term "substance." For the Scholastics it was a development of the Aristotelian "matter," generally

being defined as the "supporter of accidents" (*cf.* Locke's polemic against the circularity of the definitions "substance" and "accident"—*Essay on the Human Understanding*). This is in radical opposition to Spinoza's view of substance as existing "in itself and conceived through itself; in other words, that the conception of which does not need the conception of another thing from which it must be formed" (*op. cit.*, p. 1). Now for Spinoza the only true definition is definition of essence, not of relation; the definition of substance, therefore, differs from the scholastic definition in being irreducible, intrinsic, unrelated. It is positive, as any true definition must be. But if anything is defined in relation to anything else, that involves determination; but what is determination but a form of limitation? And limitation is negation. Therefore substance is *causa sui.* This definition of substance is in a sense a return to the φύσις of the Ionians, that is, to what is primordial and infinite in potentiality. The progress in knowledge since their day had, however, demonstrated that nothing material could satisfy these requirements; it had likewise shown (but how little has this been remembered!) that formless stuff devoid of properties is mere nonentity. Spinoza's substance, however, avoids the Aristotelian dichotomy (of a universal potentiality creating significant forms out of the formless stuff) by merely leaving out the formless stuff. In fact, it is not the least of Spinoza's gifts to have rid philosophy (not for long, however) of the useless concept of "stuff." It is this complete revaluation of the concept of substance, by which it becomes the infinite ground of all possible relations, that makes Spinoza's philosophy not only a substantival monism but

a systemic monism also. Of course, the postulation of such an entity explains nothing; its value lies in the recognition of just what must be left unexplained, and in the fact that if one such entity be postulated it precludes *a priori* the possibility of a second such substance (*vide infra*, p. 78).

If it be granted that such a single perfect being exists, how can such an entity be cognized? Here we have to distinguish definition of substance from the point of view of substance itself, and cognition of substance from the point of view of our thought. At this stage Spinoza revives the Cartesian notion of attribute, which he re-defines as "that which the intellect perceives of substance, as constituting its essence" (*Ethics*, Def. IV, *op. cit.*, p. 1). "Essence" in this case is to be taken in a somewhat restricted sense, for it is not in the "essence of attribute" to exist apart from substance. To answer the question as to what are the attributes we know, we have to divest our common experience of all that is extrinsic; of all, that is, which stands in relation to any other thing. Now the human intellect which might first occur to us as being of the very nature of an eternal and infinite attribute fails just in this, that it is limited by a human body, and that its thoughts or ideas stand always in relation to other things and not to substance itself. Therefore not human thought, but the unrelated pure activity of thought itself, is one of the attributes of substance. Spinoza does not, however, claim for thought the nature of *abstract* universal, the existence of which he denies. Thought is, on the contrary, the concrete universal (Bosanquet's term) of which individual thoughts are the abstractions (see Letter IX and annotation, *op. cit. infra*).

The object of thought is in general the idea of a material object. Now the only essential feature in any material object is its size or extension in space. Are we to call space a further attribute of substance? At first sight we are met by a difficulty of the same kind as in the consideration of thought, namely, that an attribute of substance must be one, infinite and indivisible, but in our imagination extension is very evidently divisible. Spinoza explained this apparent contradiction in his famous letter to Ludovic Meyer "On the Nature of the Infinite" (*The Correspondence of Spinoza*, trans. and edited by A. Wolf, London, 1928, Letter XII, p. 115). Here he shows how what is infinite in its own essence has been very generally confused with the infinity formed in the imagination by the successive and indefinite addition of finite quantities; a further confusion has arisen because of the failure to recognize that two numbers which are greater than any assignable number are not necessarily equal. Both these errors are illustrated by considering the number of inequalities in the space between two circles, the one contained by the other but not concentric. This number is evidently greater than any assignable number, however much of the space be considered; on the other hand, the magnitudes of the maximum and minimum inequalities are strictly finite. If we bear this principle in mind we shall realize that for purposes of reasoning we may suppose space divided into bodies, and the extension of these bodies into parts; nor does our imagination place any limits on the length to which this imaginary division may go; but as soon as we do so we cease to think of substance as such (in the attribute of extension), but only of the modes of sub-

stance. For substance conceived as such can be conceived as nothing if not infinite in essence, indivisible, and eternal. But individual objects are evidently neither infinite, indivisible, nor eternal. Extension may therefore be divided in the imagination so long as it is in reference to particular modes. But to imagine the division of the infinite attribute extension itself is to attempt the imagination of a contradiction. Thus "if anyone wishes to determine all these inequalities [*i.e.* between the two circles] by some definite number, then he will, at the same time, have to bring it about that a circle should not be a circle" (*op. cit.*, p. 120).

Extension and thought (and nothing else) are therefore what the "intellect perceives of substance as constituting its essence." Further, from the nature of substance as above defined, and from a knowledge of the attributes, there follows the central proposition of Spinoza's philosophy, namely, that there can be one substance and one only. For it is impossible to distinguish two substances having the same attribute; and if they had different attributes they would correspond to completely different realities, which no single intelligence could conceivably apprehend. There is therefore one substance consisting of infinite attributes, each one of which expresses eternal and infinite essence, and of which two are known to us.

The expression "infinite attributes" has caused more trouble to commentators than any other of the concepts at the base of Spinoza's metaphysical system. Are we to suppose that in addition to the two we know are innumerable other attributes beyond our comprehension? The hasty have at once replied "Yes; from which it follows that Spinoza's

much extolled monism is really the wildest pluralism, for there must be infinite universes corresponding to these infinite attributes". To argue thus is to reveal a complete lack of insight into Spinoza's mode of thought. "Infinite" for him is infinite in kind and in perfection; infinity and number are to him contradictory terms, since the infinite does not allow that number, which is a mere aid to the imagination in reference to particular modes, should be applied to it at all. In this connection the remarks of Professeur Brunschvicg are so illuminating that they merit full quotation: "But to limit the conception of infinite substance to a particular number of attributes is once more to introduce not-being within the womb of being, to deny in part what has been affirmed of the whole. Infinite substance can be grasped in its totality only by an infinite mind. Now the object of an infinite mind is an infinity of attributes, not indeed an infinite number, the conception of which involves contradiction, but a concrete infinity which is at the same time a unity; from which it follows that to enter into the spirit of Spinoza it is not a question, as has sometimes been believed, of trying to jolt the sterility of our imagination into bringing forth images of new worlds beyond those of thought and extension, but to deepen the notion of these two worlds right down to the primordial unity which is their common ground. Within this they are no longer isolated; they are united and intermingled, with every kind of determination of being whatsoever, sunk within the womb of this being itself" (Léon Brunschvicg, *Spinoza et Ses Contemporains*, 3rd edn., Paris, 1923, p. 66).

It is possible, therefore, that the infinite attributes might

be none other than those we know, but the totality of their content is naturally beyond the comprehension of any finite mind. On the other hand, it must be admitted that Spinoza has himself to blame in some measure for the confusion which has arisen over this matter, since his language in this connection, as in some other matters, is not free from ambiguity. Thus in the *Short Treatise* he says: "Up to the present time only two of all these infinites are known to us through their own essence" (Professor Wolf's translation, p. 52). But as Professor Roth observes, "It would be possible to maintain that, as he had failed to discover any more than two by the time he wrote the *Ethics*, he had come to the conclusion that there were in fact only two" (*Spinoza*, p. 68). Spinoza made his position reasonably clear in a letter to G. H. Schuller, written in July 1675 (*Correspondence*, Letter LXIV, *op. cit.*, p. 306). Here he refers the enquirer to *Ethics*, II, Prop. VII, Scholium, in which he likens those things which exist only in so far as they are comprehended in the attributes of God to all the possible equal rectangles contained by the product of the segments of all the possible intersecting chords of a given circle. The ideas of these all "exist" in so far as the particular circle has the properties of a circle. But the ideas of rectangles contained by the segments of two specified chords have existence (as ideas), not only by virtue of the idea of the including circle, but because they involve the existence of their rectangles. This clearly does away with the bogy of a plurality of worlds consequent on a plurality of attributes, and indicates one meaning of the infinite attributes. As to the possible number of attributes he is again somewhat evasive. He refers Schuller

to *Ethics*, I, Prop. X, which contains the statement: ". . . the more reality or being it [*i.e.* substance] has, the more attributes it possesses expressing necessity or eternity and infinity. Nothing consequently is clearer than that Being absolutely infinite is necessarily defined as we have shown (Def. VI), as Being which consists of infinite attributes, each one of which expresses a certain essence, eternal and infinite" (*Ethics*, *op. cit.*, p. 9). And (in the letter referred to) he adds: "The axiom [of this scholium] . . . we form from the idea which we have of an absolutely infinite Being, and not from the fact that there are, or may be, beings which have three, four, or more attributes."

I cannot claim, as a result of this somewhat involved discussion, to have come to any very definite conclusion as regards the possible attributes beyond the range of our mind. My own interpretation of Spinoza's views is that as a youthful searcher he may have believed that further contemplation would yield to him attributes of substance other than extension and thought; but that by the time he came to write the *Ethics* he concluded that two only were conceivable by our minds. We should hesitate to infer from this, however, that he ever seriously believed that only two exist; indeed, the above citations from his correspondence give some warrant for the contrary inference. But at the same time all the evidence goes to show that the term "infinite" as used by Spinoza has nothing to do with the idea of number; from which we conclude that his views on the infinite attributes are twofold, and that it is the failure to recognize that the term "infinite" applies to only one of them which has caused the misinterpretation. When he

speaks of "infinite attributes" he is referring to the perfection of their essence, each after its own kind; and this has nothing to do with the question as to whether others exist different in kind from those we know. On this count he is purposely guarded: for him man is far from being "the measure of all things"; therefore, while suggesting the probability of their existence, he comes to no definite conclusion, except to show that it matters not to his system whether it be so or no. For although it makes of his system an attributive dualism, this in no way detracts from its claim to be the "monism of monisms"; the attributes are what we *perceive* of the one substance; they have no independent existence outside of substance.

Our next problem is the relationship of the attributes to one another. This, being the most widely known and on the whole the most justly appreciated part of Spinoza's system, need not detain us long. This great principle, which sometimes in its original and more frequently in a modified form has been of the utmost value in modern psychology, is best expounded by means of an example. As is well known, philosophers are notoriously preoccupied with the relation between a tooth and its ache; this will serve us as well as any. At the level of naïve experience I am conscious of two things, the tooth and the ache in it; I say purposely "in it" because the general experience is that the ache is in the tooth and nowhere else. Further, I have no doubt at all that the tooth and the ache belong to different orders of realities. The tooth I call an "object" or "thing" because I can see and touch it; but because I can neither see nor touch the pain I call it a "sensation" or a "feeling." It is

true that I may say that "my tooth feels painful," but I do not really mean that literally; I really mean that the tooth-object causes an unpleasant sensation in the me-subject. We are faced, therefore, with a special case of the problem which Descartes sought so unsuccessfully to solve, namely, how a bony object embedded in a bony structure can cause discomfort to that part of "me" which receives, interprets, and ponders on, the myriad sensations which life provides me with. In other words, we are conscious of two apparently distinct, radically distinct, entities, which are somehow joined for purposes of communication with one another.

Let us carry the consideration of this unpleasant matter a step further. This abominable tooth gives a singularly piercing "stab" which makes me put up my hand to my face and mutter an imprecation. These facts show me that the communication between body and soul is a two-way one. The soul suffers the pains begotten by the body, but it may, if it will, make the body its servant to a certain extent. It cannot usually stop the toothache, but it can instruct the finger to rub iodine on the gum. The situation is as absurd as it well could be. Here is an entity which feels, thinks, wills, and the like; that is, which is concerned solely with immaterial functions, but which nevertheless receives most of its impressions from material objects, and in turn "causes" the movement of material objects.

We have already seen that Descartes' solution was the solution of the young woman who felt that her baby needed no accounting for since it was "a very little one." Descartes similarly joined extended matter to the unextended soul in

a very little extension. But this won't do. We are not yet in a position—we may never be—to say what *will* do as an explanation; but it is the present writer's opinion that Spinoza gave the clearest indication of the sort of solution which we can hope to get.

Before giving what I believe would be Spinoza's account of the toothache episode mentioned above, it is desirable to outline the manner in which the discoveries of the newly awakened science of physiology had shed light on this age-long problem.

Although the true nature of the thread-like bodies in the higher organisms had been demonstrated by the Alexandrian physiologist, Herophilus, the two-directional nature of nerve currents and the connection between the nerves and the brain and spinal cord were worked out only in the middle of the seventeenth century by Willis, the phenomenon of irritability being described by Glisson about the same time. Thus by the time Spinoza wrote the *Ethics* the account of the above psycho-physical events would have run pretty much as follows (that is, stripped of the "humours" or "essences" which were still gratuitously introduced into most physiological processes): "There is a state of inflammation surrounding the nerve-end of my tooth; this causes a disturbance to be propagated to my brain." So far the process is purely physical; by "disturbing" the broken ends of an electric circuit we may cause a "disturbance" to be propagated along the wire. The account would then proceed according to Cartesians: "The disturbance passes *via* the pineal gland to my soul, which becomes 'conscious' of a pain 'in my tooth'; I therefore 'will' my hand to apply

iodine; this I do by causing a disturbance to pass through the pineal gland to the brain, which disturbs the appropriate nerve-end, with the result that an impulse runs out through the nerve to the muscle of my hand, causing it to contract and so raise my hand, etc." To avoid misunderstanding it should be noted that the physical disturbance is a disturbance in extended substance, and as such cannot enter the soul, which being concerned with ideas alone is unextended. What the soul experiences is an idea, which is, as it were, a representation of the physical event. The *conversion* of physical disturbance to idea occurs in the pineal gland which according to Descartes is "the principal seat of the soul, and the place where all its thoughts occur" (from a letter to Meyssonier, quoted by A. Boyce Gibson, *The Philosophy of Descartes*, p. 223).

Now the above description introduces, apart from one important consideration, a superfluous entity in the soul. The whole process might, and in similar cases known as spinal reflexes does, proceed without any intervention of the soul at all. The important consideration here overlooked is that in the case of the toothache I am, to my own sorrow, conscious of the ache, of the will to move my hand, and of the subsequent movement. Now the Cartesian account having failed in just that one regard in which philosophy has to step in, and having failed by introducing a superfluous entity which could never affect the issue because of its entire lack of *internal* relatedness with the body in which the main part of the scene is being enacted, Spinoza boldly denies the separate substantial existence of "soul" and "body," "physical" and "psychical." True, the inflamma-

tion *is* not the toothache, for I may see inflammation in another person without ever experiencing any pain; but the inflammation and the ache are two aspects of one and the same event. In more technical language, there is but one substance, which exists and acts in an infinite number and variety of singular modes of which my body, my tooth, my nerves, my brain are examples. But to every so-called material object, which is a mode of substance under the attribute extension, must correspond an idea in the attribute thought. Thus the body and the idea of the body are one thing under *different* attributes; but the idea of the body and the mind are the same thing considered under the *same* attribute, *i.e.* they are identical (*Ethics*, II, Prop. XXI, Scholium, p. 73). Here there are my material tooth and my idea of it; but there is only one event which is an inflammation in the attribute extension, and an ache in the attribute thought. The miracle of interaction between extended body and non-extended mind is therefore no miracle, since there is, in fact, no more interaction than between my striking a match and the appearance of a flame "in" a glass mirror.

Although we have but touched the fringe of the problem of perception, we shall not here continue the investigation, since to do so would involve our passing far beyond the point to which Spinoza carried it, unacquainted as he was with Locke's *Essay*. It will have been noticed, however, that in describing the relation between the attributes we introduced the term "mode" without giving any definition of it. This must be our next task.

It is the merit of Spinoza's monism as compared with

that of Parmenides that whereas the latter regarded, and unavoidably so, the phenomenal world as mere illusion, the former finds its chief confirmation in the unity which physics shows to be underlying the apparent multiplicity of things. It is true that he unambiguously sets out to find the idea of the most perfect *Thing*, in which search we have already followed him; but having, as he believed, found it in the unbounded existence and eternal "activity of God," he proceeds at once to show how this One is related to the Many. The terms by which he designates the things of sense, namely, "modes" or "affections," give at once the clue to the system. No longer must we speak of "things," for this suggests self-subsistent realities, which is inconsistent with a system in which the postulation of one substance is the central feature. What in common speech we call "things" are no more than modifications of the one substance. Now whereas substance and its attributes cannot from their very nature be considered otherwise than as infinite and eternal, we know that all modes are not so. Two questions at once arise, namely: Are there any modes which must be regarded as infinite and eternal? And, What is the relation between substance and the finite modes which we know to exist, those indeed which we call individual objects? A moment's consideration tells us that such concepts as intellect and will form, as it were, the constituents of thought in general. That is to say, we can form no immediate conception of pure thought but only by means of such abstractions as will and intellect; now "that which is in another thing through which also it is conceived" (*Ethics*, I, Def. V, *op. cit.*, p. 1) is what Spinoza understands by "mode";

therefore intellect and will are modes of substance in the attribute thought. It is further evident that we can no more consider intellect and will as beginning or ending in time, or being restricted to any portion of space, than we can of thought itself; we therefore must regard them as infinite modes. In the same way motion-and-rest is a fact related to space, and as undetermined in space and time as the infinite attribute extension itself. It is therefore an infinite mode of substance in the attribute extension.

As has already been pointed out, we do not in thought proceed immediately to such infinite concepts; we are aware first of moving and thinking bodies. How, then, are these finite or, as Spinoza called them, singular modes related to the infinite substance? The answer to this Spinoza finds in his principle of determination by negation. When we speak of any body we are in reality speaking of an abstraction, that is, of something limited apart from that which limits it; for the notion of a body limited by nothing is a contradiction in terms (*Ethics*, I, 28). Further, from the recognition of its being finite follows the fact that it does not fill all space and all time, which may be otherwise stated by saying that it is non-existent in certain parts of space and time. It cannot, therefore, be cause of itself, but must be caused either by another mode, or by that which is conceived as self-subsistent, namely, substance itself. But if the former, that mode which is regarded as the cause must itself, being finite, have had a cause; thus we are landed in an infinite regress. Nor can we escape this by falling back on substance as "first cause," since to do so is only to call an arbitrary halt, and leaves the problem in the air. If, on the contrary,

we admit the existence of some perfect being, which is therefore cause of itself, we can understand how its "singular modes" are limitations of its perfection, flowing timelessly from its essence. The manner, then, in which the modes subsist in the infinite understanding of God is quite other than that in which one mode may be said to be the "cause" of another.

This discussion has led us into a further problem which is of prime importance in Spinoza's system, that of necessary or deterministic causation. The existence of final causes, except in our imagination, having been rigorously excluded, Spinoza had to account first for the constant change which characterizes the natural world, and secondly for the existence of that world. The solutions have been anticipated above, but it will now be necessary to examine them in a little more detail. First, Spinoza avoids the trap of regarding God as the transeunt cause of all things, for not only does that reintroduce in another form the dualism which he has been at such pains to remove, but viewed carefully it is found to contain a contradiction. For "a thing which is finite and which has a determinate existence" could not be produced by God immediately, since anything which follows thus from God's eternal and infinite essence must itself be eternal and infinite; but this is contrary to the hypothesis, therefore the chain of causality between finite modes is complete and closed. In apparent contradiction to this is the result already arrived at above, namely, that no finite thing can be cause of itself; hence either it is caused by an infinite thing, or there must be an infinite regress. In a sense the second alternative is true; namely, that since

modes are always conceived as in time there may be, and in fact is, an "infinite" regress in time without contradicting the conclusion that modes cannot have been brought into existence except by something *un*determined, and therefore not bound by time. This brings us to the first of the two causal problems, namely, the origin of the world. It is here that Spinoza's peculiar genius shines forth, namely, in his grasp of the meaning of eternity. "In eternity there is no 'when' nor 'before' nor 'after' " (*Ethics*, I, Prop. XXXIII, Scholium 2, *op. cit.*, p. 35); and again: "From the supreme power of God, or from His infinite nature, infinite things in infinite ways, that is to say all things, have necessarily flowed, or continually follow by the same necessity, in the same way as it follows from the nature of a triangle, from eternity and to eternity, that its three angles are equal to two right angles" (*Ethics*, I, Prop. XVII, Scholium, *op. cit.*, p. 20). This famous passage gives the clue to the solution of the problem of causality. The "face of the whole universe" follows from the *essence* of God, and without Him could have no existence. But it is equally foolish to think of God having *caused* the existence of the universe in the sense of transeunt cause involving a time element as it would be to speak of a triangle *causing* the sum of its three angles to be two right angles. In the phraseology of the Scholastics, God is the immanent cause of the world; namely, that aspect of totality which Spinoza, following their usage, termed *natura naturans*. The aspect complementary to *natura naturans* (for since the essence of God is activity there must be as part of His nature a product of that activity) is called *natura naturata*. This is not the

world as we know it, because as finite beings we can contemplate it only in the form of abstracted parts or modes. This being so, it is no contradiction to speak of one mode being the cause of another, provided we always bear in mind that we here use the word "cause" in a completely different sense from that in which *natura naturans* may be said to be the cause of itself, that is, of *natura naturata*. From this it further follows that the causality subsisting between things is a determined one, because the "face of the whole universe," of which they are finite modifications, is itself determined, not, indeed, in space or time, but in essence by the nature of God, which is in turn determined *by itself*.

This last statement is, as it were, the fount of Spinoza's determinism; and it is the doctrine which, above all others, brought down on his head the passionate denunciation of all God-fearing people. "For," they argued, "a god who cannot do as he pleases is no God, but a mere machine. This doctrine is atheism." This attitude was as incomprehensible to Spinoza as his was to them. His reply was in effect that: "A god who *can* do as he pleases is no God, but a mere human despot; human, because subject to human error in believing that he *can* do what he pleases, for of course nothing whatsoever can do as it pleases, freedom of choice being an error to which our passions born of ignorance make us fall a prey."

As far as his contemporaries were concerned, the *impasse* was complete and absolute. They were far too rooted in the prejudice of the unscientific ecclesiasticism of the Middle Ages to be able to read the *Ethics* (any, that is,

who had survived the *Tractatus Theologico-Politicus*) without boiling with indignation and thereby obscuring their vision of what Spinoza really believed. We are not, on the one hand, concerned here and now with the metaphysical validity of his determinism, nor on the other with its detailed working out in the realm of ethics, but since the acceptance of any philosophical doctrine must, and rightly so, be in a measure determined by its reaction on common sense and right feeling, it is necessary to write, as has already been done by so many loving hands during the last hundred and fifty years, that the inexorable fate which binds all things together, which determines all things with the rigorous necessity of a geometrical theorem, is no wearying repetition of a remorseless machine, nor the servitude of a ruthless tyrant, but the "service" which "is perfect freedom." The doctrine which embodies it is no bitter pessimism, but rather, in the words of its discoverer, "teaches us in what our highest happiness or blessedness consists"; it must not be so distorted "as if virtue itself and the service of God were not happiness itself and the highest liberty."

What at first appears to the casual glance as absurdity and wickedness turns out on examination to be the purest rationalism and the most rational purity. It is reason run wild, reason carried to its utmost conclusion, with relentless rigour and courage, but reason informed with a pure emotion, namely, the intuitive belief in the sweetness of reason and the goodness of its results. Not the goodness of God, let it be understood; for neither intelligence nor will belong to the nature of God (*Ethics*, I, 17, Scholium; also I, 31), since this would detract from His perfection; but

the goodness *for us* of conforming to, making ourselves one with, the process which flows necessarily from His essence.

Spinoza has been variously described as "a pernicious atheist" and a "God-intoxicated man"; neither of these appellations gives at all a just clue to his system. For though his system is manifestly not atheism, he is very far from being intoxicated; indeed, it is just his having cleared his mind of the intoxication, which most formal religious bodies are apt to induce in their followers, that enabled him, as Renan said, to see God most near. It can never be too strongly emphasized that the determinism which follows from the essence of God is none other than the determinism of natural science. For, as Professeur Brunschvicg points out (*op. cit.*, p. 21), the authentication of one single miracle would be for Spinoza a direct proof of atheism. He is in fact the first philosopher (not excepting Descartes, who was always ready to call in a transcendent deity to start any machine that went wrong) to announce in rousing, though unfortunately somewhat misleading terms, the uniform and necessary causation which was henceforth to be the touchstone of natural science. It was his preoccupation with morals, and insistence on man's being *within* and not apart from this rigorously determined system of nature, which brought upon him such uproar and slanderous denunciation. Whether he was justified in this extension of the realm of natural law we shall not at present attempt to determine; but we may greatly applaud the effort, and reasonably see in its lack of contemporary recognition one cause at least of the divorce of science and

philosophy which came about shortly after his death—much to the detriment of both.

Our study of Spinoza draws to a close. Into those paths, the ordering of our lives by the light of the highest wisdom, which were his real objectives, we shall not follow him. One last problem, however, faces us before in a new chapter we turn to the criticism of his system. In any monistic system we must urgently enquire as to what part conservation plays in the argument. The exclusion of creation carries with it that of destruction. This Spinoza fully recognized. In a letter to Oldenburg he says: "I pray you, my Friend, to consider that men are not created but only begotten, and that their bodies existed already before, although in another form. This, however, is inferable, as I freely confess, namely, that if one part of matter were destroyed, then all Extension would vanish at the same time" (*Correspondence*, p. 83). What, then, when the balance of motion and rest, which composes the body, is finally upset, shall become of the soul? Is it, being but the "idea of the body" in the attribute thought (see above, p. 86), to vanish into night, that is, to be disrupted into the ideas of the products into which the body changes at death? On this point Spinoza's teaching is open to the reproach of inconsistency. In dealing with the grades of knowledge he shows how the soul rises from common knowledge, which, being full of negations, is rather ignorance, to the life of science and reason, in which the soul, becoming acquainted with that which is common to the essence of various bodies, begins "to perceive things under a certain form of eternity" (*Ethics*, II, Prop. XLIV, Corol. 2). But, and this is important, by this

kind of knowledge nothing can be completely known, for in giving us only what is common to the essences of many bodies it yields us a complete idea of the essence of none. For this a third grade of knowledge, intuitive knowledge, is requisite. To know a thing wholly, we must, as it were, know it from within, that is, recognize its immanent cause. This kind of knowledge does not proceed by analysis, which inevitably involves the introduction of the determining factor of division in space or time, but comprehends things in their totality, as wholes acting in and for themselves. And when the mind comes thus to grasp itself, God, and things in their essence, it sees them *sub specie aeternitatis*; no longer *sub quadam specie,* as through a glass darkly, but now face to face. Nor need this illumination follow only after death; it has, in fact, nothing to do with it. Further, we may say that the reproach of inconsistency against Spinoza is based on just such a misrepresentation of his interpretation of the term "eternity," as was that of the term "infinity" which caused the dispute about the number of attributes. Eternity for Spinoza is outside time. Let us but see a thing in its whole essence and we see it "under the form of eternity," and to that extent to which we thus see God do we become One with Him and eternal. Our passions, strife, and thoughts, in so far as they are set on the transitory, shall with the death of our body, of which they are the ideas, pass away; but our intellectual love of God, which unites us with Him in eternal essence, can never pass away.

It is admittedly difficult, if not impossible, for the generality of mankind to form a clear conception of just

what is conserved; but if we feel that there is here any grave inconsistency, we should ponder before publishing the indictment, and ponder long, whether we have yet gained a complete (and the complete only is the true) understanding of those closing pages of the *Ethics*, about which, so sublime, so unearthly do they seem to us, plays fitfully "the light that never was, on sea or land."

CHAPTER V

THE FAILURE OF SPINOZISM AND THE RISE OF SCEPTICISM

THE monism of Spinoza commends itself to us by virtue of its comprehensiveness. Comprehensive in its ground, its method, and in its application. Its ground is no conceptual object (for that, being necessarily abstract, is thereby determined by negation), but the most perfect being, which from its very perfection is unknowable in its completeness, but only through two of its attributes and their modes. Its method is no mere dialectic, but the form of mathematics ordering the eternal and necessary process of nature. Its application is neither for the school nor for the study, but for man's well-being in every moment of his life. The trinity of God, Man, and Nature appears for the first time as a unity; for man is nothing if not a part of nature, and physical nature is raised to be an infinite mode of God Himself.

In attempting to assess what may be accepted in Spinoza's system *sub specie aeternitatis* we shall not attempt to follow any of the numerous "refutations of Spinoza" which flowed copiously in the years immediately preceding and following his death; for in the main they are the products of impassioned minds, repelled by the dire consequences which must necessarily impinge on established customs and religion by the acceptance of this "pernicious atheism." With such consequences we have at present nothing to do. Nor shall we make much use of Leibniz's fragment—the *Refutation*

of Spinoza—for it will be part of our purpose in considering the philosophical reaction, of which Leibniz was one of the centres, to show that his doctrine was not so thoroughly purged of "Spinozistic error" as he appears to have believed.

At the same time it is useless to deny that Spinoza's philosophy is full of difficulties and even of apparent contradictions. To many of these his attention was drawn by contemporary critics, and I shall make an effort to show by quotations from this correspondence how these major difficulties were removed by Spinoza himself. Before beginning this task, however, it is important to clear away at once the kind of difficulties which in my view were created by critics themselves, due to a misconception of Spinoza's aims and methods. Thus Ueberweg, one of the fairest of them, fell into the trap of believing that Spinoza "by strictly syllogistic procedure" "expected to secure for his system mathematical certainty." In this belief Ueberweg concentrates all his critical armoury on the logical structure of Spinoza's system, and so riddles his exposition as to render it quite valueless as a proof.

His major objection, which I find wholly just, is the double use Spinoza makes of his definitions; for these relate, in the first place, as is reasonable enough, to conceptions framed by his own intelligence, but he uses them subsequently to prove each other's existence. In Euclid's geometry, on the other hand, the definitions are also of conceptual objects—straight lines, circles, and the like—and in the subsequent deductive system it is proved that if the existence of these entities be tacitly assumed, then the existence and properties of others may be derived from them; but the

argument makes no attempt to prove the real existence in nature of objects corresponding to these concepts.

Admitting, then, that there is no question of logical unassailability of Spinoza's monism, we must consider one other difficulty raised by Ueberweg, namely, the internal contradiction of some of his definitions, and in particular that of *causa sui*. Even if Spinoza deserves the censure of critics for using expressions which are literally contradictions in terms, nevertheless these critics have not been sufficiently patient to recognize that what he means is that the category of causation is one which we have developed to account for the changes in the mutual relations of "singular modes," but that it is essentially inapplicable to substance, which, if it be conceived at all, must be conceived as causeless.

I pass now to those criticisms which, unlike the foregoing, whose interest is mainly academic, reveal the incompleteness, if not actual error, of the system itself as distinct from the validity of its demonstration.

We have already dealt with the questions of the number of attributes of substance and the nature of infinity; there remain two, namely, the derivation of the Many from the One, and the validity of his determinism. The two points are not entirely distinct—indeed it is both the merit and the difficulty of his system that its concreteness precludes the study of any one part in isolation—but for convenience we may consider them separately, as did Tschirnhaus, who brought most clearly to the fore those difficulties which would perplex men under the spell of contemporary modes of thought.

In a letter dated May 2, 1676 (*op. cit.*, Letter LXXX,

p. 361), Tschirnhaus says that he finds "it exceedingly difficult to conceive how the existence of bodies having motion and figure can be proved *a priori*, since there is nothing of this kind in Extension when we consider it absolutely." The answer of Spinoza, though incomplete, is quite unambiguous, and shows more clearly than any of his other remarks the futility of identifying his system with the greater part of that of Descartes: "Next, from Extension as Descartes conceives it, that is, as a quiescent mass, it is not only, as you say, difficult to prove the existence of bodies, but absolutely impossible. For matter at rest will continue at rest as much as possible, and will not be set in motion except by some stronger external cause. For this reason I did not hesitate to say once that Descartes' principles of natural things are useless, not to say absurd" (*op. cit.*, Letter LXXXI, p. 362). The inherent contradiction in the identification, by Descartes, of matter and extension is here laid bare. Matter as we know it is no inert changeless mass, but from the nebula to the mote in the sunbeam, a ceaseless stream and eddy, a never-ending change of position and configuration of parts. Descartes was only too ready to seize upon the Aristotelian transcendent deity to start the ball rolling. Of this fact Tschirnhaus reminds Spinoza as follows: "I should like you to do me the favour of showing me how, according to your thoughts, the variety of things can be deduced *a priori* from the concept of Extension. For you remember the opinion of Descartes whereby he maintains that he can deduce this variety from Extension in no other way than by supposing that this was the effect produced in Extension by motion which was started by

God. In my opinion, therefore, he does not deduce the existence of bodies from inert matter, unless perhaps you disregard the hypothesis of God as the mover; for you have not shown how that must necessarily follow *a priori* from the essence of God; a thing the demonstration of which Descartes believed to be beyond human comprehension" (*op. cit.*, Letter LXXXII, p. 363). To which Spinoza replies: "You ask whether the variety of things can be proved *a priori* from the conception of Extension alone. I believe I have already shown sufficiently clearly that this is impossible; and that therefore matter is badly defined by Descartes as extension, but that it must necessarily be defined by an attribute which expresses eternal and infinite essence." Once again Spinoza emphasizes that the primary conception of matter is that of activity; for as such I understand his "eternal and infinite essence." Rest thus becomes for him what modern science is more and more showing it to be, namely, the balancing of two mutually equivalent motions. Thus the gratuitous addition of a *primum movens* is removed.

Thus far, criticism of Spinoza's views has shown up their strength rather than their weakness. But in the letter already quoted Tschirnhaus had carried the matter a stage further in pointing out a grave inconsistency in Spinoza's method. In mathematics, Tschirnhaus observes, from the definition of a thing only one property may be deduced; if we require to discover other properties we must relate the thing to other things. For instance, from the definition of the circumference of a circle we may infer its uniformity of shape, but no more; if we wish to discover other properties we must relate it to the centre, or to radii, etc. This

fact of experience is in conflict with the proposition that "From the necessity of the divine nature infinite things must follow in infinite ways (that is, all things which come within the infinite understanding)" (*Ethics*, I, 16). This is the very kernel of the problem of the One and the Many; and indeed it seems evident that from one entity taken by itself we can never deduce a multiplicity of things. Spinoza's reply to this letter is to the effect that from the mere definition of God as a Being to whose essence belongs existence we may infer several of His properties, *e.g.* His necessary existence, immutability, etc. To the critic this is unfortunately mere circular reasoning; we have already exposed this fallacy of the "proof from essence" in dealing with Spinoza's method. It seems probable that he recognized that he had been driven into a corner, for in the same letter he says: "Perhaps, if life lasts, I will discuss this question with you some other time more clearly. For so far I have not been able to write anything about these things in proper order." This refers actually to the criticism of Descartes' concept of matter; but the two questions are ultimately inseparable. However, the promised elucidation of this crucial point never came; for seven months later the sweet voice was silenced, and the great spirit became one with the essence of eternity. From our present standpoint, however, it appears unlikely that even if life had lasted he would ever have been able to give a complete solution of this difficulty; indeed, it seems probable that it is one beyond the solution of finite minds.

We come now to a criticism of the validity of his determinism. But first of all it is necessary to see exactly what

Spinoza's determinism really involved; the failure to realize that in *his* mind there was no such opposition between determinism and freedom as existed in the minds of his critics caused much of their obloquy to be entirely beside the point. Freedom, for Spinoza, was synonymous with complete *self-determination*; that only is not free which is compelled by some *external* cause. God alone has perfect freedom; all other beings, in so far as they are limited, to that extent lack freedom. Now, as has already been pointed out, all finite modes are bound together in a rigorous causal chain, and the infinite modes follow from the nature and essence of God with the same necessity as the sum of the three angles of a triangle is two right angles. That is, we are the victims of external circumstance (this in turn, of course, being determined by God's essence), on the one hand, but what we are and what we do apart from that results not from compulsion, that is, is no "effect," but is an inevitable consequence of the eternal and infinite essence of God.

Two points arise for criticism. In the first case, does the above conclusion harmonize with the known facts of human existence, and with the rest of Spinoza's system? And secondly, what of the validity of the comparison of the determination of our existence with the determination of the properties of a triangle?

It has already been shown how Spinoza relates our supposed freedom of choice to ignorance and the blindness with which passions cloud our thought. Though this is a hard saying, and at the commonsense level appears nonsensical, yet upon reflection it will be recognized to be, if not true, yet nevertheless irrefutable. How can I prove that

because this morning I sat down to write these lines instead of spending an hour of pleasure in the tavern, I have deliberately "chosen the better part," and rejected as unworthy the prompting of my lower nature? How shall I ever disprove the view that it was all written in God's palm, what I should think, and what "chose," my thoughts and my decision following with the same necessity as geometrical truths? The dilemma is unresolved, perhaps on these lines unresolvable. But, as with so much of Spinoza's doctrine, however coherent internally, does it survive external criticism? How, in fact, are we to account for the possibility of error and of falling from grace? If all will be as it must be, why, or indeed how, shall we "strive to conserve our being" (*Ethics*, III, 49, Scholium)? The inconsistency is to some extent merely verbal, for in Spinoza's view sin and error have no absolute existence but are imperfect good and knowledge respectively. (This point of view is the basis of a kind of ethical relativism, which denies the validity of absolute ideals of good independent of the individual. *Cf.* R. Demos, "Spinoza's Doctrine of Privation," *Philosophy*, April 1933.) To be good also is to know God. This perhaps is the only act of freewill which Spinoza allows, namely, to seek the knowledge of God, for only so can we attain to blessedness. I speak, however, under correction; nowhere to my knowledge does he explicitly admit this choice, yet to deny it would plunge his system into rank pessimism, predestination in its ugliest form; but on the contrary, the *Ethics* glows with optimism and good will towards men: "This doctrine, therefore, besides giving repose in every way to the soul, has also this advantage, that it teaches us

in what our highest happiness or blessedness consists, namely, in the knowledge of God alone, by which we are drawn to do those things only which love and piety persuade" (*Ethics*, II, 49, Scholium). It seems, therefore, that we are free to know God more and more, or to remain in ignorance of Him.

Discussion of this matter must be closed by reference to the related one of the kind of determinism that Spinoza had in mind. The famous apophthegm of Spinoza, that all things flow from the nature of God "by the same necessity, in the same way, as it follows from the nature of a triangle, from eternity and to eternity, that its three angles are equal to two right angles," stirred the wrath of various critics in different ways. To the Scholastically minded the analogy between the nature of God and that of a triangle was so blasphemous as to be rejected without further consideration; but to the more thoughtful and unprejudiced it appeared to be false on purely rational grounds, namely, that a triangle is an artefact of the human mind, having no existence beyond that (*cf.* Leibniz: "But he gives no proofs of his assertion, that all things follow from God, as properties from a triangle, nor is there any analogy between an essence and an existing object"—*Refutation of Spinoza*, trans. by O. F. Owen, Edinburgh, 1855). This being so, whence comes it, by what rigorous necessity, "from eternity and to eternity," that its three angles be equal to two right angles? Namely, from the axioms and postulates of Euclidean geometry; fictions, that is, though this was unrecognized in Spinoza's time, depending for their relative truth on the particular view of spatial relations holding sway in Alex-

andria in the fourth century B.C. Generalize the possible metrics of space and your postulates are found to hold good no longer, but others must be substituted, whence it may be actually shown to follow that the three angles of a triangle are *not* equal to two right angles. So much for the rigorous determinism of Spinoza's metaphysics. Or rather so much for any semblance of *proof* of it; for if we look further into his mathematical comparisons, which play so big a part in his exposition, we see that there is nothing in them of the Euclidean *spirit* even if the state of mathematical knowledge available to him precluded his use of any but the classical forms. He goes so far, indeed, in his first letter to Tschirnhaus as to state his preference for defining a circle as a figure traced out by the motion of a line one of whose ends moves while the other is fixed—"since this definition expresses the efficient cause" (*op. cit.*, Letter LX, p. 300). Without doubt, then, Spinoza was free from the error which would regard geometrical figures as ideas inhabiting celestial realms beyond the accidents of time and place. (An illuminating account of Spinoza's use of geometrical analogies is given by Professor Wolf on page 59 of his edition of the *Correspondence.*) But this cuts both ways. On the one hand, it does away with the sterile interpretation of his metaphysics as a logico-mathematical relationship, but, on the other hand, it weakens the superficially compelling phrase concerning the triangle and its properties. In my view the matter reduces to this: That when Spinoza states that things flow from the nature of God with the same *necessity* as the properties of a triangle flow from its essence he speaks truth, but relative truth. For the stated properties of a

triangle depend on the truth of certain undemonstrable premises, just as the proof of God's existence, however approached, always involves some circularity.

We have now heard the more important indictments which contemporary and later critics have drawn up against Spinoza's system; and we have seen that when due allowance has been made for his confusing terminology and his double use of geometric analogy, most of these criticisms have been due to the failure of the respective critics to "get inside" Spinoza's own viewpoint. There remains one apparent weakness, however, which carries most weight among modern critics (*cf.* J. Ward, *A Study of Kant*, Cambridge, 1922, p. 10 *et seq.*), namely, that the whole system seems to be based upon his failure to recognize the difference between cause and effect in nature, and ground and consequent in logic. This interpretation of Spinoza's system rises from three striking aspects of one central problem, namely, the derivation of properties from a definition concerned with essence, the doctrine of necessity consequent on it, and the use of geometrical analogy to illustrate this consequence.

I have already indicated my view that Spinoza's misuse of his definitions in logical argument nullifies his attempt (if he ever really had this in mind) to render his system logically unassailable. I have also shown what I believe to be the correct interpretation of his use of geometrical analogy. But of the third aspect of the central problem, namely, the precise nature of the relation between the ground and its consequences, whether merely logical or truly causal, I shall not here speak; but I shall ultimately

urge the view that the distinction is a verbal one, and would never have arisen had his critics sounded as deeply as Spinoza did the ultimate relations between time, duration, and eternity (*infra*, p. 401).

Despite its lack of dogmatic grounding, we may, then, regard Spinoza's philosophy as the most comprehensive and daring flight of man's unifying imagination. In the full and cautious setting out of its prolegomena, and in its discovery of fertile concepts by which the whole tissue of experience hangs together without break or seam, it stands revealed as the inevitable starting-point of every future substantival monism. Its failure to achieve this without the collocation of an attributive dualism is a salutary warning to his successors of the "ultimate irrationalities" beyond which it is impossible for human minds to pass; moreover, in the recognition of the ontological status of this duality as a bifurcation in the conceptual form of apprehension it "saves the phenomena" without recourse to the miracle-working of the Cartesians. Finally, it has shown that the essential hollowness of all substantival monisms whose substance is characterized by what Professor Whitehead calls the "baseless metaphysical doctrine of undifferentiated endurance" (*Process and Reality*, p. 107) can be avoided by a reshaped form of the conception of substance as the *prius* of all other concepts.

Among his contemporaries, however, Spinoza's failure was as great as in respect of so great an intellect it could possibly be. Prejudice, misunderstanding, and the inability to follow his brilliant anticipations of future tendencies had done their fell work. This great century of great minds

turned away in contempt from the task of seeking a unity and concreteness in reality. It is astonishing how such keen intellects as Newton, Pascal, and Boyle could have dissipated so much of their energy in theological controversy of a reactionary nature. Nevertheless this recognition of the failure of the Cartesian-Spinozistic synthesis was not without its value, for it is not unlikely that as a result more attention began to be paid to the problem of knowledge and the nature of perception.

The leader of this new school of philosophers, who denied the possibility of forming any coherent system of reality until the problem of knowledge had been solved, was Locke. He is of importance to our study in three ways: as the discoverer of many fertile notions bearing on the philosophical status of natural science; as the founder (with Hobbes) of empiricism, in the clear air of which the young plant of natural science was able to thrive more vigorously than in the storms of dogmatic controversy; and, negatively, as the reviver of the pernicious doctrine of secondary qualities. Of his positive contributions I shall speak at a later stage. The last only of the above aspects of his thought will be discussed at this point, since its iniquity was the principal thorn which pricked Berkeley's mind into making two of the greatest philosophic advances of all time.

According to Locke, when we perceive a body we perceive two distinct sets of qualities. The primary qualities, which belong to the body intrinsically, are extension, figure, motion, and number; none of the other qualities which we attribute to the body, such as small, colour, and the like, inheres in the body, but is, as it were, fastened by our minds upon it;

such qualities he termed "immediate secondary," to distinguish them from the "mediate secondary qualities" or "powers," which are inferred from the given body's action on others. Locke has been sternly censured for making this distinction between primary and secondary qualities, and no wonder, since it is evidently the thin end of the Kantian wedge of the unknowable. But with the advances in physics and physiology, whereby was provided a mechanism for the transference of the qualities of a body to the sense organ, and thence to the brain, it was almost inevitable that someone should fall into the trap of regarding objects as "nothing but" extension decked out with sound and colour by the individual consciousness. Curiously enough, however, Locke fell into complete miracle-mongering when he further postulated the mind as a *tabula rasa*; how a blank tablet, even admitting with Locke that the expression is purely figurative, is to create bright colours and sweet odours out of mere corpuscular or elastic movements is hard to imagine. Locke was the perfect Englishman, modest, clear-sighted, and at time marvellously inconsistent. His merit in regard to perception was to recognize and clearly reaffirm the *subjective element*. His confusion of the concept of matter was exposed by Berkeley: his travesty of the intellect was corrected by Leibniz.

In his diatribe against "material substance" Berkeley began where Locke left off. Is there any direct sensation, he asks, to convince us that the moon is a spherical solid? None whatever. Our belief in its solidity springs from tactual associations derived from handling other visible bodies. Until we have touched a body, and in so doing added

to the visual impression the notion of movement, or distance traversed, we can have no notion of solidity. What, then, becomes of extension as an abstract general idea? It is as much added by the mind as colour or any so-called secondary qualities. Further, all such abstract general ideas are mere contradictions; no human mind ever has formed a general idea of a triangle; discussions of properties of triangles are not discussions of "triangularity," but of all possible triangles without reference to the properties of any particular one. And so with matter; no general idea can be formed of matter; and that of which no idea can be formed cannot exist.

Two errors have thus been removed at once: the error of Locke in basing much of his reasoning on the formation of abstract general ideas; and that huge sham, material substance, thrust upon the world by Aristotle, protected and revered by the Middle Ages, and given rather more than nodding recognition by Descartes. Material substance has been annihilated; but before we are fully free from the crushing weight of this incubus our limbs are caught in the tenuous folds of another paralysing monster. Matter in general counts for nothing, but minds are everything. It must not be supposed that Berkeley committed errors as gross as those he rid the world of: he makes no claim, as Descartes did, for mind-in-general; but since he recognizes the existence of the phenomenal world *somewhere,* he is driven to declare that "all those bodies which compose the mighty frame of the world, have not any subsistence without a mind, that their being (*esse*) is to be perceived or known; that consequently so long as they are not actually perceived

by me, or do not exist in my mind or that of any other *created spirit*, they must have no existence at all, *or else subsist in the mind of some eternal spirit*" (italics my own). That Berkeley was prepared to consider an alternative view is urged by Mr. J. B. Mabbott in an article on "The Place of God in Berkeley's Philosophy." He quotes as follows from the Commonplace Book: "Bodies, etc., do exist even when not perceived—they being powers in the active being" (*Journal of Philosophical Studies*, No. 21, p. 22). Now this may well be, but it is not the exclusive inference from his perfectly just views on perception. Of course once he was committed to *esse est percipi* the postulation of an all-comprehending deity was the only escape from solipsism or magic. But see what metaphysic this postulate leads us to, something intermediate between occasionalism and Spinozism; for unless there are to be innumerable special creations in all times and places, those persons and things which we see about us must persist as ideas in God's mind, as must ourselves also. Berkeley's system may be regarded as a spiritual counterpart of atomism; it postulates a *plurality* of substances, whose subsistence in the mind of God constitutes an attempt at systemic monism.

Berkeley, of course, was hotly opposed to occasionalism and pantheism, which he regarded as rank heresy. But nothing is more usual in the history of philosophy than to find a pair of its principal figures blackguarding one another's systems, which to later critics appear to have much in common (*cf.* Kant and Berkeley, Leibniz and Spinoza).

The findings of Berkeley in regard to the problem of

knowledge have had the utmost consequence for natural science; for by extending them still further in the light of Kant's critical philosophy Mach, Pearson, and others founded the modern doctrine of phenomenalism, which has dominated the outlook of men of science almost to the exclusion of any other. On the other hand, by starting with Berkeley's interpretation of perception, but avoiding his "mentalism," Professor Whitehead and others have in recent years restored to realism much of its former prestige, much to the benefit of British philosophy in general, which has for too long lain under the shadow of Hegel. But of these we shall have to speak at length in the Third Part of this work.

By his contemporaries, Berkeley's terse and penetrating study met with the same contemptuous and contemptible reception as had Spinoza's. Dr. Johnson's famous "refutation" by the kicking of a stone is only a more dramatic example of the state of ignorance and mental inertia which the general run of the "learned persons" of any age bring to bear on a new mode of thought. One only had the patience and insight to see where Berkeley's central thesis really led, namely, to complete scepticism. This doctrine it would have ill-behoved the Bishop of Cloyne to publish abroad, but Hume fortunately was deterred by no prejudicial scruples. If matter is non-existent, why not mind also? We have no more evidence of self-subsistent mind than of self-subsistent matter. Both are bundles of impressions, given a seeming reality by association. Likewise for causation, which is the recognition of regular sequence hardened by habit into a metaphysical dogma. Though, as Professor Whitehead says,

"it is difficult to understand why Hume exempts 'habit' from the same criticism as that applied to the notion of 'cause.' We have no 'impression' of 'habit'" (*Process and Reality*, p. 196).

Contemporaneous with Hume, influencing him and being in turn influenced by him, was the reign of scepticism and materialism known as the French Illumination. We shall not, however, treat of this here and now, for there falls now to be studied the true reply to Spinozism.

Before we could pass on to the further development of the monistic concept we had to examine, however superficially, the new views on metaphysical speculation engendered by the growing realization of the mechanism of sensation and perception. That these new views were not wholly sound we may probably infer from the fact that they led to complete scepticism. There was, however, an alternative path to that which we have so far followed; this has already been mentioned in connection with Locke, namely, a further enquiry into the nature of perception: an enquiry which culminated in the refutation of Locke's *tabula rasa* view of the mind. It so happened that this investigation was carried out by the philosopher who by time and temperament was also the most suited to supply an alternative metaphysic to that of Spinoza. We may, as I hope to show, not irrelevantly devote the whole of the next chapter to an examination of the philosophy of Leibniz.

CHAPTER VI

LEIBNIZ AND SPIRITUAL PLURALISM

THERE has probably been almost as much nonsense written about Leibniz's disposing of the wicked folly of Spinozism as of Spinoza's having merely plagiarized Descartes. The truth is probably that so sensitive, so cosmopolitan a mind as Leibniz's must inevitably have been much influenced by any fertile views that were "in the air"; but he seems to have had rather less than average power of recognizing the sources of his own streams of thought. It is not our business to enter into an exact assessment of his obligations, but what does appear most profitable to be undertaken is the attempt to show to how great an extent his relapse into substantival pluralism served to clarify and complete Spinoza's monism. Further, in justice to Leibniz, and very much to our own advantage, we shall have to pass in review those fertile concepts of monad, entelechy, and the like, which he rehabilitated or introduced; and above all, to describe that revolutionary change he initiated into both mathematical philosophy and method by the creation of the differential calculus.

The failure of Spinozism had, we have seen, three aspects: that which to the majority of his commentators appeared contradictory but which to others offers no stumbling-block; that which by virtue of the obscurity or incompleteness of his exposition must for ever remain doubtful, and as such render unstable the main position; and last, the

inherent imperfection due to the gaps in Spinoza's mathematical equipment and scientific knowledge.

Leibniz, with his customary perspicuity, seized at once on the imperfections of the second and third kinds, but he seems also to have fallen into the trap that so many others have done, namely, in not sufficiently familiarizing himself (he admits having had only a few hours' conversation with him; his acquaintance with Spinoza's system was based on this, on the reading of the *Ethics*, and on "conversations with his followers") with Spinoza's mental temper and background before beginning the refutation of that philosophy against which, by virtue of its apparent inconsistency with Christianity, he was from the start strongly prejudiced. He naturally could not reconcile himself with its pantheism, its insistence on determinism, its relegation of the human soul to a mere aspect of a certain natural mode. But he went further, and struck at the root of the whole system in denying the validity of Spinoza's conception of God as the one perfect being. To the idea of God as infinite essence, Leibniz adds infinite potentiality; for him the most real is not only the most perfect existent, but the most perfect of all possible beings, having in his power the creation of all possibles. Now we shall have argued in vain if this concept of Leibniz be regarded as an advance on that of Spinoza other than merely in the precision and clarity of its enunciation. It may well be that Leibniz did a great service to Spinoza in comparing their two concepts with such disadvantage to the latter's, for had it not been for his formal statement of the concept, that which we believe to be latent in Spinoza's might ever have remained so. The

whole question turns on the exact nature of Spinoza's mathematical imagery. That he was but a mediocre mathematician was attested by Leibniz himself with a gesture that came needlessly close to a sneer; but it is not necessarily the most facile mathematical manipulators who have the clearest sense of the philosophical import of mathematical processes. Plato was a mediocre geometrician; but it was he, and not Theaetetus, who saw in the ideas of geometry a pattern of all reality. Spinoza, we may believe, with a halting instrument, but with the clear eye of faith, pressed the analytical geometry of Descartes into realms far beyond those for which the latter had fashioned it. A general equation was no longer a concise statement of the relationship of points, but a general pattern or form having within it the potentiality of movements of a point in infinite ways after one kind. God, the infinite equation, had infinite potentiality, that is, determines with rigorous necessity infinite possibilities in infinite ways.

Leibniz, on the other hand, was a better physicist than Descartes, who, though he held Galileo in high veneration, paid him the doubtful compliment of drawing a number of false conclusions from his laws of kinematics (*vide supra*, p. 60). Leibniz, however, recognized that not the quantity of motion in a system, but, as it were, the potentiality for creating motion, or *vis viva*, was the point to be grasped. His, therefore, was the inestimable service of reshaping the concept of energy, and setting it forth in the unambiguous terms of mathematics. That he was far in advance of his time in this is shown by the fact that only in the closing years of last century was his distinction between force and

energy fully recognized and applied. Now the philosophical superstructure which Spinoza, with his Neo-Platonic and Scholastic tradition, had with mathematical figures of some obscurity erected on the physical concept of potentiality,[1] this, Leibniz, a citizen of the modern world, with clarified mathematical rigour and more thorough grasp of the physical questions involved, carried out in unambiguous terms; and, in the outcome, with complete freedom from the unpalatable consequences which Spinoza had been unable to avoid. So great, however, was the difference between the temperaments of the two philosophers that Spinoza looked upon Leibniz with considerable suspicion, who returned the compliment by somewhat contemptuously "refuting" the very basis of his own philosophy!

The next step (the order of exposition here is that of my own convenience; the actual chronological development of Leibniz's philosophy does not concern us) was the relation of individuals to God. Here Leibniz breaks away entirely from Spinoza, and comes to accept substantival pluralism. He posits no single substance from which the variety of individual existents should be derived; but, as it were, turns Spinoza's method inside out, starting from a clear idea of the individual and working thence to the idea of God. If this statement appears to be in contradiction with the above discussion of the basis of his philosophy, it should be borne

[1] *Cf.* A. Wolf, "Spinoza's Conception of the Attributes of Substance," in *Proceedings of the Aristotelian Society*, 1927, pp. 177 ff. Professor Wolf identifies Spinoza's "extension" with "physical energy," in a very broad sense of the latter term. The concept of energy in general is, I think, too ill-defined to be identified with an abiding principle such as "extension" (*vide infra*, p. 324).

in mind that our task here is to relate Leibniz's system to Spinoza's; our purpose to show the strong resemblance between them. It must happen, therefore, that not until the discussion is concluded will apparent contradictions be resolved. Since Spinoza's system is developed out of, and turns entirely upon, the conception of God, it was inevitable that we should have seized upon that element in Leibniz's world-view which most closely resembled it; but we are not urging that this is the *complete* description of the idea of God in the latter's philosophy; this can be realized only after the nature of individuals has been set forth.

The approximate identity of the two philosophers' insistence on potentiality as the basis of reality being admitted, the reason for Leibniz's method, being what it was, namely, the attempt to fit individuals into a comprehensive system, was, I think, that unlike Spinoza, whose mathematics was mainly formal, Leibniz was interested primarily in mechanics. Spinoza delighted in the derivation of spatial forms from an equation; for Leibniz the cardinal task was the finding of an equation for the accurate description of a system of motions. As a result, whereas Spinoza started with infinite, pure, unique potentiality, Leibniz, partly perhaps also as a result of his supposed demonstration of the former's failure, turned towards the *beau ideal* of "mechanical" metaphysics, namely, atomism. History was thus far seen to repeat itself; the One of Parmenides sundering once again into the atoms of Leukippos; but with great difference. Leibniz, realizing at once that an infinite number of non-extended entities could in no wise constitute extension, and further that "material substance," whether

divisible or not, was an empty figment, postulated for his atoms not ultimate material particles, but ultimate units of that alone which appeared to be complete and substantial in the true sense of the term, namely, soul. In his own words: "Since multitude can only have for its reality *real unities*, and as real unities are a quite different thing from mathematical points, for it is agreed that the continuous cannot be composed of points. . . . I was obliged to have recourse to a formal atom. . . . I found that their nature consists in force, and that from this there ensued something analogous to feeling and desire, and so it was necessary to conceive them in the likeness of the notion we have of souls" (quoted from an article in the *Journal des Savants*, 1695, by H. Wildon Carr, *op. cit.*). History has therefore repeated itself still further; the atoms have had once again to be *beseelt* (animated).

Now since the soul-atoms, or "monads" as Leibniz (following Bruno) later called them, formed the material and texture of his metaphysic, it will be necessary to dwell some little time upon them. And this careful analysis of the classical example of spiritual pluralism is necessary not only in justice to the point of view opposite to that with which we are chiefly concerned, but also as showing that a substantival pluralism, if it is to escape the accusation of being a collection of *ad hoc* hypotheses, must incorporate in its framework some form of systemic monism.

Before we can form an adequate notion of the psychic quality of the monad we must make a brief reference to Leibniz's criticism of Locke's theory of perception.

With Locke's view that there can be no knowledge

without sense perception Leibniz had no quarrel; but when Locke went further and in effect stated that there was *nothing* in the intellect prior to sense perception, Leibniz cunningly corrected the dictum by the simple addition of "except the intellect itself." In other words, it was inconceivable to Leibniz how a structureless entity could give structure to the raw material furnished by the senses. Perception was for him the one pervasive factor in reality. "Simple substances are what we call souls, and of these all nature is full" (quoted from a letter to the Electress of Hanover by H. Wildon Carr, *op. cit.*, p. 60). But although all substances perceive, they are not all conscious; this latter faculty is what characterizes the rational soul, which thereby partakes of the nature of God.

The above very condensed statement may be put otherwise, thus: Since material substance is only a figment, and since from any mechanical process nothing but another mechanical process can be inferred, perception is caused neither by matter nor by any mechanism; it is therefore no compound, but a simple substance—indeed *the* simple substance. But since it is unwarrantable to suppose that stones and even trees think, we must distinguish perception, which is that activity in which the existence of bare monads or entelechies inheres, and apperception, which is the activity of those monads which have memory and to which the term "soul" is conveniently restricted (*Monadology*, trans. by R. Latta, Oxford, 1898, p. 230). Nevertheless, it is not thereby implied that there is any hard-and-fast line to be drawn between the two; on the contrary, Leibniz has pointed out that in confused perceptions we have actual

evidence of the probability of a continuous gradation in the rise to self-consciousness from "the pebble to the angel."

We may return now to a more particular study of the monad. The bare monad is, we have seen, a simple potentiality for perception and appetition; as simple it must be eternal, for destruction is merely the disintegration into parts, and the monad has no parts. We have now to investigate the relation of the monad to the universe, to bodies, and to God.

The relation of the monad to the universe is the old problem of the One and the Many. We had best quote Leibniz's own words (letter to the Electress of Hanover, cited above): "I shall be asked how the composite can be represented in the simple, or the multitude in the unity. I reply that it is in much the same way as an infinite number of rays meet and form angles in the centre of a sphere, simple and indivisible as the centre is. And these rays do not consist only in the lines, but also in the tendencies or efforts along the lines, which are cut without being confused together, as the movement of fluid helps us to understand." The dynamical character of Leibniz's thought is here well brought out, and in the next paragraph more fully still, where he reminds his correspondent of the independence of different interpenetrating waves on the surface of water, each proceeding from a centre. In its activity the monad radiates, as it were, its influence in all directions and to infinity; in its power of perception it receives influences from every other monad. Each monad therefore "is a perpetual living mirror of the universe" (*Monadology*, § 56, *op. cit.*, p. 248). But it is to be remembered, on the other

side, that the simplicity of the monad precludes any possibility of change being induced from without; on the contrary, the influence of a monad is to be traced to a continuous unfolding of its inner nature (hence the alternative term "entelechy," *Monadology*, § 18, *op. cit.*, p. 229).

The monad stands in quite a different relation to its body and to other bodies. Monads themselves, however low in the scale of acuteness of perception, are yet real; however high, are yet imperceptible as such. Bodies, on the other hand, are as it were created by the monads as representations of the imperceptible reals. Thus there are in truth neither time, nor space, nor bodies in motion; for all these are complex objects, that is, divisible; they can then be nothing else than the relations between the monads. The body of each monad is the outward relational expression of its own activity; therefore there is no absolute life or death; life being the unfolding in the body of the monad's inward potentiality, death the re-encasement. Of this we have powerful evidence in the findings of the microscope, which not only shows us a world of living creatures within a drop of water, but within every animal the animalcular prototype of the next generation. (But see later.)

We commenced this brief study of Leibniz's philosophy with an attempt at interpretation of his concept of God. To this in respect of its relation to the monads we must now return. Leibniz recognizes only two principles of reasoning, namely, that of contradiction, and that of sufficient reason; and he uses both of these to prove the existence of God. First, since analysis of the connections of the infinity of things in the universe, however far it may be pressed, can

never yield a necessary, but only a contingent reason for their existence, there must be a necessary reason outside the series. "Thus the final reason of things must be in a necessary substance, in which the variety of particular changes exists only eminently, as in its source; and this substance we call God" (*Monadology*, § 38, *op. cit.*, p. 238).

This is the cosmological argument restated in the more rational terms of Leibniz's own concepts; but, in that it provides no *necessary* reason why the uncaused[1] origin should give rise to a system in which each of whose members is bound to the rest by a network of causes, it is still defective. This Leibniz corrected by introducing the concept of God as supreme monad, that is, the unity which contained ideally the possibility of the rest of the universe. There is difficulty here in recognizing what exactly is meant by creation. The words of Leibniz are as follows: "Thus God alone is the primary unity or original simple substance, of which all created or derivative monads are products and have their birth, so to speak, through continual fulgurations of the Divinity from moment to moment, limited by the receptivity of the created being, of whose essence it is to have limits" (*Monadology*, § 47, *op. cit.*, p. 243).

This is really for us the crux of the whole system; but we have one more detail to examine before pausing to sum up and criticize the whole.

Since no monad can be influenced to action by any other, how comes it that the body moves at the soul's behest?

[1] "The sufficient reason which has no need of a sufficient reason must be outside the sequence of contingent things. It can only be found in a substance which is cause of itself" (quoted from *Principes de la Nature et de la Grâce*, by H. Wildon Carr, *op. cit.*, p. 120).

To none of the "solutions" of this problem can Leibniz subscribe. Descartes, in postulating the power of the soul to change the direction though not the quantity of motion, had done so in ignorance of the conservation of direction of moving bodies (*Monadology*, § 80, *op. cit.*, p. 264. *Cf.* Newton's first law, "A body remains in its state of rest or uniform *rectilinear* motion except, etc."). The solution of Hobbes, namely, that "mind" is as material as body and can therefore act directly, has been shown to be false at the root (see p. 63 *supra*). The only remaining solution is that of occasionalism, which involving a perpetual recurrence of miracles was roundly denounced by Leibniz (in a letter to Foucher), who pointed out that a miracle is none the less a miracle for being of uniform occurrence. The solution given by Leibniz is based upon the relation between created monads and the supreme monad described above. "But in simple substances the influence of one monad upon another is only ideal, and it can have its effect only through the mediation of God, in so far as in the ideas of God any monad rightly claims that God, in regulating the others from the beginning of things, should have regard to it. For since one created monad cannot have any physical influence upon the inner being of another, it is only by this means that the one can be dependent upon the other" (*Monadology*, § 51, *op. cit.*, p. 246). This is the famous doctrine of pre-established harmony, which has been variously described as artificial or miraculous. For us it is the reasonable outcome of the preconceived relationships. If these are just, so is it; but this is not to say that it affords any real "explanation."

We have now passed in review the principal elements of

Leibniz's *Weltanschauung*; it will next be necessary to see to what extent he has escaped any form of monism; and in so far as he has escaped it, to what extent he has improved on it.

First in regard to substance. That of material substance there is none, is implicit in Spinoza's, explicit in Leibniz's system. For both, substance is something active, charged with potentiality. The apparently diametrical opposition between the two systems appears at the next step. Whereas Spinoza avers that there is only one substance, which is God, Leibniz points to the plurality of existents which he suggests can be explained only by the supposition of a plurality of active substances. The latter seems far the more reasonable; but before we pass on we should be satisfied that the term substance is understood by both authors in the same sense. Now Spinoza defines substance as "that the conception of which does not need the conception of another thing through which it must be formed"; Leibniz, on the other hand, says: "The Monad, of which we shall here speak, is nothing but a simple substance. . . . By simple is meant 'without parts' " (*Monadology*, § 1, *op cit.*, p. 217). Now whereas Spinoza proves that only the most perfect thing can be *conceived* (he has not, in my view, *proved* that it necessarily exists) without the aid of some other conception, Leibniz does no such service for the individual monad; indeed, it is at least open to question whether the monad can be conceived at all; for although "where there are no parts, there can be neither extension nor form nor divisibility" (*Monadology*, § 3; § 2, *op. cit.*, pp. 217–18), yet extended objects are only compounds or

aggregates of the monads. There appears to be a contradiction here, which is only partly cleared up by the view stated elsewhere that extension has no real existence but is merely the relation between objects. Further, even granted that the monad may be conceived, Leibniz has nevertheless to admit that it cannot be conceived *entirely* without the conception of another thing, namely, another monad; for the existence of a monad is to perceive, but in the absence of all other things whatsoever there would be nothing for it to perceive; it would therefore be non-existent. If a monad is to be called a "substance," then it must be only a subordinate substance such as extension and thought in the Cartesian system.

So much for the ontological status of the monads; what of the cosmological? From this point of view there seems at first to be no more reason why the monads should not be *causa sui* than that God should be so. Rather, perhaps we should say, no less; for both are equally contradictory. It is quite true that it passes our understanding how the monads could ever have come into existence, since no external influence can affect them one whit (*Monadology*, § 11). In other words, no sufficient reason can be given for their existence other than in something which is outside the series. And "as this substance is a sufficient reason of all this variety of particulars, which are also connected together throughout; *there is only one God, and this God is sufficient.*" From the postulated existence of the monads we therefore conclude to the existence of a creator; from the observed order of existents we exclude the possibility of more than one.

We have still to examine the relationship of the monads to God their creator (whatever that may mean, *vide infra*) from the ontological point of view. Leibniz's doctrine is that God is the supreme, perfect, and necessary Monad, *i.e.* if God is possible, *i.e.* involves no contradiction, then He exists. Although He stands "outside the series," He is nevertheless, so to speak, reflected in the created monads in varying degrees according to their several powers. How is this to be reconciled with the previous argument? This turns on the meaning of the term "creation." If we argue back to the existence of a primitive cause by virtue of our instinctive search for "something before," we cannot in consistency place that primitive cause outside the category of causation. But if we put it within the category either we make it a term in the infinite regress, that is, if we conceive its power as transeunt, or we make of it a World Soul, that is, conceive it as the immanent cause. But this is a return to Spinoza, with the monads thrown in as a gratuitous hypothesis. Leibniz, however, thought that there was an alternative to this, namely, that the monads are "fulgurations from moment to moment" (see p. 124 *supra*). In the absence of any further elaboration of this dictum we cannot escape a feeling of scepticism as to whether Leibniz did, in fact, avoid the dilemma of a miraculous creation on the one hand, and some form of pantheism on the other.

As regards substance, then, it seems that monism has not received from Leibniz the rude shock that at a superficial view appears to be the case. What of the relationship of mind and body? With Leibniz's solution, the pre-established harmony, we have no quarrel. Granted a system of indi-

vidual centres of force brought into existence by one act of will, it is not surprising that the monads all beat out the harmony of creation as two clocks, however different in size, shape, and ornament, will yet, if made by the same master hand, beat out the hours in perfect accord, just as if one had complete control over the other. We say that this is a rational inference from the data of the system; but it is no more: it constitutes no sort of explanation. Granted that in itself it is no miracle, it is still ultimately dependent on the miracle of creation.

We must now, on the basis of this necessarily brief statement and commentary of Leibniz's system, endeavour to arrive at a just estimate of what were his contributions to the concept of monism. Part of our task is already accomplished, in that we believe we have shown that his substantival pluralism will not stand on its own feet as such, but can be made into a self-consistent system only by borrowing monistic concepts. Rejecting the one pure potentiality of Spinoza, and sundering it into an infinity of different centres, each simple but having its own individual capacity differing from that of every other, he yet had, in order to account for the existence of only one such universe, and one in which law and order reigned, to bring that pluralistic hierarchy into causal relationship with one, sole, origin. This failure to put a pluralistic system in the place of the unacceptable monism of Spinoza was, however, the least of his gifts to philosophy. Rather in the modernity of his outlook, in the fertility of his imagination, shall we find much that was of permanent value not only to philosophy in general, but to the further moulding of the concept of monism in particular.

We have already referred to the cardinal service which Leibniz rendered to mathematics, but we shall here show how this new point of view enriched philosophic speculation. Unlike Newton, who based his "method of fluxions" on the hypothetical flow of a still more hypothetical time (that is in the assumption of a continuum where none may be found), Leibniz expressed his "differential calculus" in terms of the limiting values of vanishing quantities in general. This conception, he admits, gave him the hint for passing from "mathematical entities to real substances" ("Transitus datur a rebus Mathematicis ad substantias reales," *Opuscules et Fragments,* edited by Couturat, p. 342, quoted by L. Brunschvicg, *op. cit.*); that is, he at last recognized the true nature of abstraction. Without abstraction there can be no knowledge; but we must refrain from hypostasizing our abstractions, which Descartes had failed to do. The relation of whole to part is given precision in the relation of integral to differential; for though the differential itself is no real thing but a convenient abstraction, yet by its use we may learn something concerning the whole (that is, the integral) which was impossible without it. The differential must therefore be, as it were, an abstract view of the essence of that whole of which it is a part. The relation of the whole to the abstraction was clearly shown by Leibniz in the determination of the point by the sphere. He avoided the error of regarding a point as an infinitesimal sphere; they belong to different orders; for whereas a sphere, or in strictness we should say "a wooden sphere" or "an iron sphere," can be perceived, a point, on the other hand, can never be more than a concept. It is as useless to speak

of a sphere becoming so small as to be a point as it is t suppose an enlarged point becoming a sphere; but ther is no harm in saying that a series of concentric sphere of diminishing radii determines the idea of a point. Th use of the term "concentric" does not involve begging th question, since the concept of such a series depends on th notion of symmetry. The common centre is secondary (The notion was first treated fully by Professor Whitehea under the name of "extensive abstraction.") Leibniz nowher develops it quite so explicitly, but it is evident that it germ is present in the following words: "The essence c substances consists in the primitive force of action, or i the law of the kind of changes such as is the nature of numerical series" (*Lettres et Opuscules*, edited by Foucher d Careil, 1854, p. 303, quoted by L. Brunschvicg, *op. cit.*, p. 386) We have here, then, a far more articulate conception of sub stance than Spinoza's; but the nature of its definition doe not bind us irrevocably to a pluralistic universe; indeed, a I have shown above (p. 127), Liebniz's definition of sub stance contains a possibility of contradiction. For if w admit a thinker's right to define his terms in any way h chooses, then we must coin a new word for the "prio principle" in which, as I have attempted to show, th monads must inhere.

We must next say a word about Leibniz's views on th relationship of the living to the non-living. His genera attitude, as being bound up inevitably with the very textur of his system, I have already described; but he elaborate this in one or two important particulars.

In the first place, we may reverence him for being probabl

the first, and certainly the last, mathematician (until comparatively recent times) of the first rank to cast his views on biology in so sympathetic a mould as to appreciate both its importance and its difficulties. With Leibniz, biology ranks as an autonomous branch of natural science: autonomous in the sense that it cannot be "reduced to" mathematical physics. On the contrary, it was from the microscopical observations of Malpighi, Swammerdam, and others that he derived an absolutely essential feature of his thought in general, namely, the relativity of magnitudes in nature as well as in mathematics. When we enter a drop of water by means of the microscope, we enter into a world within a world; we see, and in a measure share, the ceaseless and complex activities of a host of creatures of various kinds and habits; nor must we regard this adventure so much as the magnification of the drop, as the reduction of our scale of reference; for in another way we may come upon the same sort of experience without the use of any instrument, namely, in finding on close examination the teeming life in that which from afar appeared to be no more than a still piece of water. There is here more than a mere suggestion of the complexes of organized matter by which biologists are tending more and more to lay bare the secrets of life. Of this, however, I shall have to speak at greater length in the Fourth Part.

The dangers of basing a metaphysical system on the shifting ground of scientific hypotheses is, however, equally well exampled by Leibniz's other biological views. An essential part of his system was the doctrine of the ebb and flow of the tide of life in every organism without its ever

drying up entirely. "There never is absolute birth nor complete death, in the strict sense, consisting in the separation of the soul from the body. What we call *births* are developments and growths, while what we call *deaths* are envelopments and diminutions" (*Monadology*, § 73, *op. cit.*, p. 259). The paragraph just quoted, together with several others in the same part of his book, show that he has seized upon the supposed *facts* of "preformation" to support his view of worlds within worlds, wherein is constant change but neither complete generation nor complete destruction; indeed, in another place he refers specifically to the "direct experiments of Swammerdam, Leeuwenhoek, and M. Dodard" (letter to the Electress of Hanover already cited). But he adds that it is not only these "but reason itself which leads us to this conclusion, namely, that there is no complete separation of soul from body. For there is no mechanical principle by which a body endowed with an infinite number of organs, such as an animal's, can be derived from a formless mass." We see, then, that although he called in support of his thesis facts which subsequent investigation has shown to be no facts at all, but faulty interpretations due to the crudity of early microscopical technique combined doubtless with the prejudices of the observers, which enabled them to see what they wished to see, he nevertheless is anticipating a principle, the truth of which modern work is unable to explain away, namely, that the organism is a fundamental datum of experience, not to be "reduced" to a purely mechanical basis.

Although Leibniz's writings are an inexhaustible mine of suggestions which demonstrate that one side of his outlook

was more modern than that of most of his contemporaries, and certainly more so than that of many latter-day men of science, we must draw this account, already stretched beyond the confines of our immediate problem of the monistic concept, to a close. Enough has been said to show that the philosophy of Leibniz, if it has neither completely "refuted" nor displaced that of Spinoza, has to a remarkable degree completed it. Nowhere is this more apparent than in regard to the interrelations of the concepts of natural science, concerning which Spinoza was largely ignorant. It is interesting to speculate how much swifter might have been the progress in philosophy had not Newton's preliminary scholium to Book I of the *Principia* placed its cramping influence on the successors of Liebniz, driving the more fruitful conceptions of the latter into the background, from which they have re-emerged only in recent years. In all our future searches for a monistic basis of metaphysics, then, though we may strive to order it on the pure and lucid model of Spinoza, we shall nevertheless have to take into account many of the modifications shown to be necessary by the wider view of Leibniz.

CHAPTER VII

PHILOSOPHY AT THE CROSSROADS

WITH the death of Leibniz in 1716 we may reckon the end of the greatest century of progress in science and philosophy since the beginning of time. Despite a generous crop of errors resulting largely from enthusiasm outrunning experience, the lines of advance in nearly every branch of science had been mapped out; the philosophical implications of this huge mass of information had been seized upon with a comprehensiveness which is astounding. When one recalls the fact that philosophy and mathematics were for Leibniz rather leisure-time pursuits to be followed during the intervals in his main task of writing history and conducting diplomatic business, one wonders whether the human race is not perhaps now past its prime; but, however this may be, one seriously suspects that it was the absence of professional interest and atmosphere which gave to the writings of Descartes, Spinoza, Locke, Berkeley, Hume, and Leibniz that freshness, that suggestiveness, which makes of them even to this day the sources of inspiration to which we naturally turn in search of new ideas on old topics.

With Leibniz's death there passed away the last chance of philosophy becoming in the modern world what it had sought to be in Greece—a way of life. For, though one of the two great camps into which philosophers divided sought to make of philosophy a very slave of convenience, their efforts were foredoomed by enchaining it within the narrow

circle of the senses. Of the French Illumination we must speak later, seeing that upon its principles was founded that kind of monism to which alone men of science were for a time attracted. But it was not the main line of progress in philosophy, the apostolic succession of which now for the first time shifted to Germany.

In its new home philosophy underwent a profound change, the most important aspect of which, for us, was its separation from natural science; a divorce which had the most unhealthy consequences for both. Since this work is mainly concerned with the possibility of a monistic interpretation of nature, little need be said by way of apology for the somewhat scant way in which the great philosophies of the late eighteenth and early nineteenth centuries are to be treated here. But it should perhaps be recalled in passing, lest an accusation of one-sidedness be laid against the author, that there has at no time been in his mind any intention to write a complete history of monism, but only to examine somewhat closely those philosophies which have played the chief parts in the fashioning of the concept, so that a clear understanding of its varied implications might be gained. Now in the performance of this task very drastic rejection has to be carried out if the argument is to be kept within workable limits and the discussion restricted to a reasonable compass. It is essential therefore that our study of the post-Leibnizian period be much less detailed than that accorded to those who, in my opinion, are the masters.

In what follows, therefore, an attempt will be made to describe that great principle of Kant which has to be reckoned with by "every future metaphysic"; thereafter

to select and assess only those aspects of later philosophies which seem to enrich and define the monistic concept. Many great names will be but lightly touched upon; many minor monistic systems, in which no new light is shed upon the central principle, will be left unmentioned. In the present chapter we shall consider Kant. In the two concluding chapters of this Part we shall deal with post-Kantian idealism and realism down to the end of the nineteenth century.

As the title of this chapter suggests, Kant found philosophy at the crossroads—in fact, somewhat beyond the crossroads; for whereas Wolff in systematizing the various strands of Leibniz's teaching claimed for mind the exclusive right to existence, the same claim had been made by de la Mettrie, Condillac, and Diderot for matter. The circumstances of his early life inclining him to espouse the former cause, Kant wrote and argued in its favour for many years, until working from Locke forward to Hume he was roused by the latter "from his dogmatic slumber." Not only had Hume denied the possibility of proving the existence of matter, but by showing, as he thought, the absence of any *a priori* basis for the notion of causation, he had cast grave doubt upon the independent existence of mind. Kant's claim to immortality need be based upon nothing else than that he alone recognized that "Hume's problem" was the key to the apparent *impasse* which had been reached between idealism and materialism. This he did by returning to the "*nisi ipse intellectus,*" which Leibniz had added to Locke's "*nihil est in intellectu, quod non prius fuerit in sensu.*" But with a difference; for whereas Leibniz had further inferred

the pre-eminence of minds, Kant, appreciating the cogency of Hume's attack, recognized that it is not in any exclusively mental existence that cognition can arise, but in the *relations* between the percipient and the objects of perception. "All our knowledge begins *with* experience . . . but it does not therefore follow that it all arises *out of* experience." And it is the first business of the *Critique of Pure Reason* to show that such, in fact, is not the case.

In attempting a brief summary of Kant's argument and results in so far as they have a bearing on the concept of monism, we shall avoid as far as possible all the side-tracks, inconsistencies, and irrelevancies which make this great classic so confusing to any but Kant specialists. Hypnotized by the existence "already at hand" of a bundle of neat labels in the form of the logical categories, Kant looked for that which could be the basis of the recognition by us of all the others; the category of relation evidently stood out as the dominant one, reason consisting of nothing but relations. Thus far he was at one with Locke and Hume; but whereas they had not passed beyond the recognition of judgment as the idea of a relation between concepts, Kant saw that this gives no hint as to the *source* of the relation; in other words, relations imply "a concept of a higher order" than their terms. We are to understand, then, that the subject and the object are as it were abstracted from the "apperceptive synthesis"; for the perception of the stream of formless sense data as involving the existence of an "object" is unthinkable except to a percipient subject aware of its own unity and continuity. This "transcendental unity" of the percipient subject derived from the recognition of the

"synthetic unity of apperception" is not only a corrective to Humian scepticism in that the possibility of forming a concept of causation demonstrates the existence of an "understanding" of a higher degree of complexity than a mere aggregation of associated impressions, but also inverts the subjective idealism of Berkeley. For though the "understanding" (as will later appear) fashions the data of sense into the facts of experience, nevertheless there must be objects independent of the understanding, else the understanding would be non-existent. Kant admits that his philosophy is idealism, but "transcendental idealism."

If Kant had been satisfied with this triumphant overthrow of scepticism, and on the basis of an equally enlightened psychology had sought to point out the direction in which philosophy must henceforth proceed, namely, in the recognition of *verae causae* instead of the hypostasizing of abstractions, his would have been a cardinal service if less magnificent than the path he actually followed. Unfortunately the friendly greeting of science and philosophy rendered possible by the recognition of the synthetic unity of knowledge was rudely brushed aside by the consequences of Kant's unholy reverence for artificial schematism.

This passion for sharp distinctions, and orderly arrangement based thereon, is evident in most of Kant's writings, but nowhere does it play such havoc with his thought as in the search for the origin of concepts. Rightly rejecting all theories of their purely sentient origin, he then proceeds to ignore the one firmly established ground of speculation, the synthetic *unity* of apperception, and points to certain "pure conceptions of the understanding" as lying "ready at

hand," whereby the understanding may prescribe to nature her laws. "The understanding draws its laws—*a priori*—not from nature, but prescribes them to it" (*Prolegomena*, § 36, pp. 67–8, trans. by E. Belfort Bax, London, 1883). The inevitable consequence of this is that natural science, though true knowledge, is nevertheless knowledge only of phenomena and not of noumena, or things-in-themselves.

With this remarkable inversion of common sense Kant was well pleased, likening it to the throwing off of naïvely realistic prejudices which enabled Copernicus to see the true basis of astronomy; but as Ward so clearly puts it: "The simpler description which Copernicus advocated exalted the universe and humbled the earth; the bold paradox which 'exaggerated and absurd though it sounded,' Kant nevertheless attempted to uphold—exalted the knowing subject and banished beyond the limits of knowledge the whole universe of things *per se*" (compare also J. Ward, lecture on "Immanuel Kant," *Proc. Brit. Acad.*, 1922, p. 240). This not only arises out of false analogy but leads to irreconcilable conclusions. The false analogy is due to another of Kant's obsessions—the existence of mathematics as the prototype of all *a priori* knowledge (*Prolegomena*, § 38, *op. cit.*, p. 68). The main contradiction into which it lands us is that although nature is according to Kant the product of the understanding, nevertheless the unknown and unknowable reality behind it enters into the category of causation. How that which is unknown and unknowable can be thought of as existing at all, let alone as a cause, was never elucidated by Kant. The double vision to which Kant was so prone is well illustrated by his contempt for

metaphysics, dogmatic metaphysics that is, which is summed up in the following retort to a critic: "High towers, and metaphysically great men resembling them, round both of which there is commonly much wind, are not for me" (*Prolegomena*, Appendix, *op. cit.*, p. 124). And yet surely the recognition of the *Ding an Sich* is metaphysics in the worst sense, namely, as "knowledge of the unknown"; for though of course no objection can be taken to a philosophy which accepts the existence of a boundary to the knowable, yet to postulate the existence of "things-in-themselves" is to negate the principle of the synthetic unity of apperception. A "thing-for-God" is doubtless different from a "thing-for-me," and I can never know it; but of the possibility of existence of a thing-for-itself we can have no knowledge (*cf.* Whitehead, "The subject emerges from the world"—*Process and Reality*, p. 123).

We have said enough to enable us now to assess his contribution to the fashioning of the monistic concept. We must first reaffirm that Kant at his best is critical in the ordinary sense of the term. Thus when he says that "If, therefore, reason employs in the complete determination of things a transcendental substrate that contains, as it were, the whole store of material from which all possible predicates of things must be taken, this substrate cannot be anything else than the idea of an *omnitudo realitatis*" (*Critique of Pure Reason*, translated by N. Kemp Smith, London, 1929, p. 490), and again, "The concept of an *ens realissimum* is the concept of an individual being" (*op. cit.*, p. 490), we may at first conclude that he is tacitly accepting the One of Spinoza; but on reading further we are told that "These

terms are not, however, to be taken as signifying the objective relation of an actual object to other things, but of an *idea to concepts*. We are left entirely without knowledge as to the existence of a being of such outstanding pre-eminence" (*op. cit.*, p. 492). We are left, then, with the cold comfort that if we are to have any metaphysic of reality, reason dictates that it shall be monistic; but since neither reason nor anything else can give us any knowledge of things-in-themselves, of which this reality, according to Kant, consists, it leaves us pretty much where we started. Indeed, our last state is worse than our first, for though we may suspect that the totality of the possible is one, we are nevertheless compelled to *act* in accordance with the sharpest dualism—the old dualism of matter and form in new transcendental dress.

We shall not attempt further criticism of this result, but merely add by way of summary that Kant's metaphysic (for in view of the *Ding an Sich* it is idle to pretend that he has escaped the dogmatism which he so severely censures) has added little or nothing to the concept of monism. Indeed, when we consider the paradoxical conclusion with which he seems so well satisfied, it is perhaps not unreasonable to question whether it was not rather from Kant's than from Berkeley's brain that the cobwebs needed to be swept (*cf. Prolegomena, op. cit.*, p. 40).

When we restrict our attention to his treatment of the problem of knowledge, however, the matter is quite otherwise; for he has here, if incompletely, at least soundly, grounded epistemological monism (*cf.* Dr. Eisler, "In the history of monism, it is not as a metaphysician that the

founder of the Critical Philosophy, I. Kant, has to be considered"—*op. cit.*, p. 50; and again, "No monism will be tenable which is not at any rate critically founded"—*op. cit.*, p. 54). Though the problem of how mind cognizes physical objects is still with us, in the transcendental unity of these two constituents of experience we have a solid gound on which to build our explanations.

There is still much to be said about Kant's far-ranging thought; but the discussion of his vital contributions to physical and biological principles will be postponed until the history of these principles comes to be discussed in later sections.

In what remains of our search for the basis of monism we shall separately follow the two routes which Kant unfortunately reintroduced in the form of phenomenon and noumenon.

Kant's successors laid undue emphasis on this distinction, with results that he himself would probably have disowned. Thus, on the one hand we have the "idealistic" succession of Fichte, Schelling, Hegel, Schopenhauer, and others, who identified the task of philosophy with the investigation of just those parts of reality which Kant had branded as unknowable. On the other hand, there arose an heretical band, who seized upon Kant's distinction as justifying the relegation of metaphysics to the study of the non-existent, while placing natural science in the equivocal rôle of being both the only true knowledge and at the same time affording no explanation of reality as such. Both lines of thought, being pursued during a period of culture when it was the fashion to close the eyes firmly on any views or facts which

were at variance with the accepted standards of thought and conduct, degenerated into a self-sufficient dogmatism which naturally soon brought about their downfall. Nevertheless, to each school of thought belonged some first-class minds who, after the nature of such, were never sufficiently confined within the limits of the doctrines of their schools to be prevented from putting forth new views, which have been of value in the shaping of philosophical concepts.

To the former of these groups we shall now turn.

CHAPTER VIII

IDEALISTIC MONISM AFTER KANT

AT the head of this movement stands Fichte. He saw, and with characteristic courage emphasized, the reactionary nature of the sundering of appearances from things-in-themselves. The unity of apperception, having once been established, cannot be set aside at one's convenience. So far there is nothing in Fichte's teaching to criticize; but his next step, though not, I think, in any way a necessary consequence, set the narrowing fashion we have already remarked on. This was to deny any self-subsistent reality to the phenomenal world, which exists not for itself but only for the Ego. This at first seems to be merely a roundabout route to the position of Berkeley; but the pluralism of the latter is softened by the qualification of the Ego as being not any individual Ego, but the primordial Subject, which is the common element in all individuals. Indeed, he expressly states that the world is independent of the individual Ego as such.

In Fichte's system we have the first example of dogmatic idealistic monism; that is, a kind of metaphysics which dogmatically asserts that cognitive mind, *i.e.* the Primordial Subject, is the only reality, all else being derivative therefrom. It is difficult, if not impossible, to refute categorically the basis of idealism; but in my view it must be rejected on the grounds that it is based on prejudice, and that by denying to nature any reality independent of mind it

renders philosophy of negligible relevance to life in the modern world.

The prejudice here referred to is the unwarranted primacy given to the experient subject in the transaction known as perception. The devaluation of the physical world to which this inevitably leads is such that philosophy at once loses what is perhaps its most valuable, because its most realizable, rôle of being the critique of scientific concepts; and this, in an epoch when the deliverances of science permeate all our modes of thought, is nothing less than a disaster.

I shall make no attempt, therefore, to analyse these idealistic monisms *qua* systems, but extract from them such critical and constructive views as have relevance to any form of monism in which the world of nature stands at least on a parity with that of mind.

The Fichtean "Primordial Subject," which is the "substance" of his idealistic monism, was converted by Schelling into a principle of indifference known as the "Absolute." This was seized upon by Hegel, who created from it the most comprehensive philosophical system of modern times. With him, as earlier with Spinoza, substantival monism attained to perfection, and, by virtue of the unwarranted presuppositions underlying it, extinction. To one aspect of his philosophy we must, however, draw special attention, namely, the dialectical unfolding of the thing-in-itself to the condition of thing-in-and-for-itself, or concrete universal (Eisler, *op. cit.*, p. 60; Bosanquet, *The Principle of Individuality and Value*, Vol. I). This concept was later elaborated by Bosanquet into a regulative principle of great value; and,

in that its validity is largely independent of whether we accept the general Hegelian position or not, this value is likely to be permanent.

Quite contrary to the Hegelian position, but in the tradition of Kant, stands the original and enlightening, though at present somewhat overlooked, contribution to thought by Schopenhauer. That aspect of Schopenhauer's doctrine which stands out as of paramount importance for our present study is the correction or completion of Kant's analysis of the thing-in-itself. For the latter the concept of thing-in-itself arose merely from a consideration of the cognitive faculty of the Ego; and as such has necessarily but a ghostly existence. Schopenhauer, on the other hand, unable to reconcile himself with the existence of an unknowable agent at the basis of reality, believed that it is in his conative aspect that the experient subject comes to grips therewith. It is only by voluntary movement, and by no amount of voluntary perception and cognition, that the subject becomes fully aware of himself and external objects. Subject and object, therefore, are bound in the relationship of Will rather than of thought, which is dependent on the former. More precisely put, objects have no self-subsistent reality but are the objectifications of Will, at first blind, but rising to consciousness in the percipient subject.

We should expect that such a system would shed some light on the vexed question of causality, and such is the case. Rigorous causal connection obtains between phenomena, but the latter being no more than the conditions under which Will manifests itself to us, the causality is to be regarded only as functional interdependence, that is, as a

principle regulating the acquisition of knowledge, and not as an ultimate inhering in things themselves.

As regards living creatures, though their actions are to be interpreted as the result of physico-chemical interaction, yet binding these together, whereby the organism becomes adapted to its environment, is that stage between Will and objects which Schopenhauer calls the "life principle." If the introduction of this principle at first savours of the dualism inherent in every form of vitalism, a little consideration should dispel this conclusion; for we must bear in mind that "physico-chemical forces," *qua* forces, are but manifestations of Will in the sphere of its conditioning manifestation, matter. The life principle is therefore not radically different from those forces, but is Will manifesting itself in a higher grade of complexity.

Though Schopenhauer recognized no evolution in the Darwinian sense, since to have done so would, of course, have wrecked his denial of the existence of design and end, yet in those creatures possessed of mind we are not to see any transcendental distinction from those without. In the former, Will, which in the latter is blind instinct and urge, rises to conscious desire. Body and mind are neither two distinct entities, nor yet different attributes of one; they are absolutely identical. There is but one real, namely, Will, which in so far as it regards itself as such is soul; but in the world of appearances, as object for itself, it is body: "*Mein Leib und mein Wille sind eines*" (quoted by Eisler, *op. cit.*, p. 66). There is thus no call for the postulating of interaction between mind and body. The volition to move, as a whole, does not precede movement, but is one with it. If

this be regarded as obviously untrue, since I may will to move and then change my mind and not do so, the correction is to be found in the above words "as a whole." For a will to move which does not merge into movement is no true will, but a mere impulse, which is rather of the nature of a thought about willing to move, belonging, therefore, to a different category of events from true volition, which is inseparable from action. To regard volition and action in the relationship of cause and effect is to misunderstand entirely their true nature. This is really the kernel of Schopenhauer's system, and that aspect of it which, although forming an integral part of an idealistic philosophy, anticipates quite clearly certain modern realistic psychologies (*cf.* William James's theory of emotion; also the general basis of the more recent "behaviourism").

Schopenhauer's system may be described as voluntaristic substantival monism. If his statement, "*Mein Leib und mein Wille sind eines,*" can be accepted categorically, his monism extends to the attributes of substance; but in view of the necessary distinction between "willing" and "thinking about willing" this is open to question. For even if "thinking" is not to be taken in its ordinary sense, the two discharges—mere impulse and action—appear to refer to different realms.

With Spinoza he denies any freedom of choice: "Man does always what he wishes, but does it of necessity" (quoted by Eisler, *op. cit.*, p. 67). But whereas Spinoza uses this as a link in the argument to the perfection of God and the blessedness of the man who joins in the intellectual love of Him, Schopenhauer draws precisely the opposite

inference, namely, that all is purposeless striving, for the Will is without reason, love, or plan. So far from his philosophy being branded as optimistic pantheism, it must be accepted as pessimistic atheism.

This result reveals only too clearly the danger of any thoroughgoing monism, namely, that the two systems starting from very similar, if not identical, premises may end in diametrical opposition, through, it may be, a personal bias of the thinker, or as a result of one strand of evidence having been overlooked. If Schopenhauer's pessimism agreed with the facts, it would be as difficult to controvert *in essence* as we have seen Spinoza's optimism to have been. But it must be an eye sadly misted by self-deception that refuses to see among the children of men any striving towards a perfection that is not theirs. Though the idea of progress is far more complex than the early thinkers imagined, though there is indeed no orthogenetic path—yet among the manifold backslidings, contentions, and follies of travailing humanity may be discerned a constant striving towards a good, though one but dimly perceived. God is not mocked; no, nor in the long run is man either. If his God is dethroned, he will quickly find another, even if, as in the case of Nietzsche, it be but a glorified form of himself.

The feeling for this concept of value became more explicit in the teaching of Münsterberg, a representative of that class of idealists who, while admitting the validity of the world constructed by natural science, nevertheless decline to regard it as anything more than an abstraction from a whole, which is alone real. The whole, for Münsterberg, is

value, striving towards self-realization through the hierarchy of individual wills.

Of exceptional interest to us is the system of von Hartmann. The basic principle of this system is that we have no justification in ascribing either an exclusively "mental" or exclusively "alogical" character to the thing-in-itself. Both aspects of the world exist on a parity, but at the same time never in complete isolation. That which renders the ideal possible is Will; but without logical idea Will is pure confusion, if not absolute impotence. But—and it is here that the originality of von Hartmann's thought is most striking—this common ground of reality is, if not "mental," which involves subjectivism, far less material, and hence must be regarded as spirit (*Geist*), though wholly unconscious.

We are evidently dealing with transformed Spinozism, in which a start is made once more from pure undifferentiated being, having within itself the power of self-realization under two attributes, here will and idea. But the comparison with Spinoza is less valid for the working out of the details, since von Hartmann rejected the dialectical method, and argued inductively from the data of natural science. Thus bodies consist of atoms, which though not self-subsistent are nevertheless real appearances or modes of the One. These atoms, which resemble the monads of Leibniz, he called *Dynamiden*, and defined them as "systems of all simultaneous actual and potential activities of force [*Kraftäusserungen*] having the same point of intersection" (quoted by Eisler, *op. cit.*, p. 75). Extension is the outcome of the activities of these unextended units; matter the sensuous appearance of certain defined equilibrium configurations.

When he comes to deal with organisms he departs entirely from the standpoint of Spinoza, and of the majority of men of science. For him all causality is ultimately teleological, with which, taking the word in a sufficiently wide sense, we may not necessarily disagree. But when we are told that organisms originated from the inorganic as a result of the operation of organizing, adaptive forces which still guide and direct existing organisms, we are at once plunged into vitalism; for it is but a small step from such vaguely clothed forces to a naked and unashamed entelechy. Both are equally unknown; both provoke equally sceptical thoughts as to the soundness of the monism which includes them. Nevertheless, von Hartmann argues with considerable acuteness and more insight than many of his countrymen in regard to the light shed by Darwin's hypothesis. Thus he realizes that though instincts are readily interpreted as unconscious strivings towards some adaptive end, natural selection, on the other hand, is a purely negative process, the emphasis being more correctly laid on elimination than survival.

We have finally to consider his views concerning the body-mind problem, which is naturally fundamental for any form of monism. With remarkable foresight he defines the soul as "the unity of the unconscious psychic functions," a conclusion which modern analytical psychology is more and more tending to vindicate. Psychic phenomena alone are conscious, psychic acts wholly unconscious. As unity the soul is necessarily discrete, but integral rather than "mere sum" in Hume's sense. Of great interest also is his view that many psychic phenomena, though "conscious" for the

lower orders of organizations composing the organism, may remain below the threshold of the central system. The unconscious acts in a double capacity, namely, as an event in consciousness and as movement. These in themselves are only functionally joined, but they nevertheless correspond to an underlying interaction whereby the soul has power to direct the motions of the body without the utilization of physical energy. Here again, in trying to overcome the somewhat shadowy correspondence of the attributes taught by Spinoza, von Hartmann is driven perilously close to the assumption of the Cartesian miracle. True, body and mind in themselves are no longer interacting, but the validity of supposing that a "function" or collection of "functions" (the soul) in which energy has no being can "direct" an object (the body) which has energy is at least open to question, savouring as it does of a second term in an infinite regress.

Contrasted with von Hartmann's conception of the one sole ground of reality is Lotze's system of monads. The development of this system has striking resemblances to that of Leibniz; but Lotze frankly admits what Leibniz, in his conceptions of pre-established harmony and the supreme monad, hinted at, namely, that the existence of an order of relations presupposes a unity beyond the apparent diversity. His critique of his own cosmological pluralism, whereby he is driven to ontological monism, is in itself so illuminating, and in regard to its results stands in so close a relation to that which I shall ultimately urge, that I make no apology for quoting his own words at some length. "In the course of our consideration of the world we were led, at

the outset, to the notion of a plurality of Things. Their multiplicity seemed to offer the most convenient explanation for the equally great multiplicity of appearances. . . . It was as so many independent unities that we supposed them to enter into such peculiar relations to each other as compelling their self-sufficing natures to act and react upon each other. But it was impossible to state in what this transition from a state of isolation to metaphysical combination might consist, and it remained a standing contradiction that Things having no dependence on each other should yet enter into such a relation of dependence as each to concern itself with the other, and to conform itself in its own states to those of the other. This prejudice must be given up. There cannot be a multiplicity of independent Things, but all elements, if reciprocal action is to be possible between them, must be regarded as parts of a single and real Being. The Pluralism with which our view of the world began, has to give place to a Monism, through which the 'transeunt' operation, always unintelligible, passes into an 'immanent' operation" (H. Lotze, *Metaphysic*, English trans. edited by B. Bosanquet, Oxford, 1884, pp. 124–5).

Truth can be learned only by viewing the complex of things as a whole; the belief in the existence of individual self-subsistent entities among which arises a system of relations is merely a failure to distinguish between what is really given and what is merely "a movement of thought which begins with a false supposition and afterwards, under the pressure of problems which it has itself raised, seeks in imperfect fashion to restore the correct view which it should have had to start with." Further, "Relations which

did not previously subsist between independent things can never begin to subsist" (Lotze, *op. cit.*, p. 128).

When, however, we set out to discover in what this relation between the One and the Many consists, we must soon admit that this task is beyond our reach. Many, indeed, are the figurative expressions—such as "radiation," "emanation," "attribute," and the like, which throughout the history of philosophy have been applied to this conception; but when all is said and done they remain mere verbal labels for an unimaginable condition. They are at one in denying the self-subsistence of individuals, but positive definition of the bond give they none. This is no proof, however, of the inaccuracy of the monistic doctrine. On the other hand, there does seem to be an objection of a far weightier character, namely, that to identify the One with the Many is to deal in contradictions, or to misuse language. On the contrary, argues Lotze, unless we are to be allowed to assume that a real thing may partake of opposite characters simultaneously without thereby being reduced to nonentity, thought becomes impossible. The phenomenon of change or becoming stands here in the forefront. Nothing is more evident than that one body may change gradually into another totally different; yet at what moment can we say that it has ceased to be itself? At any ideal instant the principle of identity is satisfied; but in the end the idea which was at first real has become unreal, and *vice versa*. "Therefore, if we want to *think of* Becoming, we have to face the requirement of looking upon being and not-being as fused with each other. This, however, does not imply that the import of either idea is apprehended otherwise

than as identical with itself and different from the other" (Lotze, *op. cit.*, p. 135). Lotze goes further, and warns us that "the like over-estimate of logical principles, the habit of regarding them as limitations of what is really possible, would oblige us to treat as inadmissible the most important assumptions on which our conception of the world is founded. All ideas of conditioning, of cause and effect, of activity, require us to presuppose connections of things, which no thought can succeed in constructing. For thought occupies itself with the eternally subsisting relations of that which forms the content of the knowable, not with real existence and with that which renders this existence for ever more than the world of thoughts" (Lotze, *op. cit.*, p. 137). The more general recognition of this salutary warning from one who was himself a master of the art of framing "logical principles" would have prevented the accumulation of much of the dialectical jungle which surrounds the problems of existence. It will be made much of in the sequel (*vide infra*, p. 393 *et seq.*).

One other contribution of the idealist school has played an eminent part in the clarifying of the concept of monism, namely, the recognition of the possibility of what Fechner called the *Nachtansicht* (night-view) and *Tagesansicht* (day-view) (Eisler, *op. cit.*, p. 78). What for the former is a system of quantitative relations between soulless atoms is for the latter the experience of a conscious mind. So far the idea is little in advance of the "double aspect" view of Bruno and Spinoza; but where Fechner has increased the fertility of this view is in giving it a surer psychological basis. The distinction between soul and body, nature and God, rests

not merely in the possibility of a substance possessing more than one attribute, but on the inherently necessary distinction between the appearance of an object for itself and for external observers. My brain appears to me always as mind in that it is only in its mental activity that I am aware of it; the activity of another's brain, however, is never directly accessible to my awareness, hence it is only as brain and nerve complex that I perceive it. Yet there is, in fact, no difference. What is for itself purely psychic is for others purely physical; but to these two aspects corresponds but one reality. Although incorporated by Fechner in an idealistic monism, the thing-for-itself being in his view primary, his view serves equally well as a regulative principle in any realistic philosophy (*vide infra*, p. 392).

Fechner's view was carried forward by Wundt, for whom both sides of experience—mental and physical—are equally real, but the mental alone is immediate, the physical being abstract, and exhibited as a sum of quantitative relationships between conceptually determined centres of action. And these centres of action in their for-themselves aspect, that is, regarded as individual "wills," constitute reality. But these individual wills are not substantial monads; on the contrary, since the concept of substance is easily derivable from our thought concerning the presentational object, but the reverse process cannot be carried out, they are "not active substances, but substance-producing [*substanzerzeugende*] activities" (quoted by Eisler, *op. cit.*, p. 99). This apparent pluralism is seen to rest on a basis of systemic monism when it is realized that they have "reality merely in so far as they are mutually connected, and their

mutual determinations are in this sense more real than they themselves" (quoted by Eisler, *op. cit.*, p. 99). The world is indeed an unfolding of deity. In God causality and finality are one: "Every conclusion of a causal series is a necessary consequence, in respect of which the preceding event in the series is as much determined by the consequence as the latter is by it" (quoted by Eisler, *op. cit.*, p. 100).

There is much more in Wundt's thought that is of considerable interest for our thesis, but we must content ourselves with mentioning but two of his views (voiced, it is true, by others of his contemporaries also), which are playing to-day a leading part in the scientific approach to reality. Of these, that in which he emphasizes that the world of the physical sciences is a closed system, and as such must not be expected to furnish complete information concerning ultimate metaphysical truths, has been several times emphasized by Sir Arthur Eddington (essay in *Science, Religion, and Reality*). The other, namely, that the rigid substance of natural science as the solid point of reference of conceptual thought is the complete antithesis of the ultimate basis of reality which is ceaseless process and becoming, forms the basis of Professor Whitehead's cosmology, who, however, unlike Wundt, does not identify it with active Will.

At this point we shall turn to consider the development of the monistic concept from the point of view of realism.

CHAPTER IX

REALISTIC MONISM BEFORE HAECKEL

It is important that the term "realistic" should be clearly defined from the start, for its uses have been even more varied than that of its opposite, "idealistic." And at this stage we are expressly concerned with this opposition, and not with the deeper epistemological question of the meaning of the term "real." Let me say at once that the connotation of realism in the scholastic sense is to play no further part in this section of our discussion: that the idea of a table has more intrinsic reality than the table I am writing on may very well be true, but it is not the doctrine of the schools of thought with which we are to deal in this chapter.

Previous to Kant's criticism, what may be called "classical realism" had already ceased to exist; for although at a superficial glance Berkeley's philosophy may seem to assert something of the kind, a moment's consideration will reveal that all that Berkeley denies is the *material* reality of the table I am writing on; with abstract general ideas he would have no truck whatsoever. The ideas in God's mind are this table and that table and not tables-in-general, for though we may conveniently construct the class-concept "table," we cannot possibly form an *idea* of it. It was perhaps the chief pragmatic merit of Berkeley that he first clearly laid bare the error of confusing "ideas" and "concepts," a confusion into which later philosophers have nevertheless frequently fallen.

The only sense, then, in which we shall apply the term "realism" is in that which denies the priority of mind, without necessarily thereby affirming the priority of matter. This definition results in the recognition of two classes of realists: namely, Materialists, who affirm that matter alone exists *per se*; and those who while denying any real existence to matter equally deny *priority* to mind. Of these the former alone exerted any great influence in pre-Kantian philosophy; and indeed much of the post-Kantian realism quite evidently has its origin in materialism.

As we have already seen, modern materialism arose from the succession of "negative" philosophers, Locke, Berkeley, and Hume. Each one seems to have believed his chief mission in life to be to destroy some one of the foundations of existing philosophy. For Locke it was "innate ideas," for Berkeley matter, and for Hume mind. Posterity has not wholly confirmed this view of these great thinkers; for instance Professor Whitehead has shown that both Locke and Hume held views whose development might have avoided the *reductio ad absurdum* which Hume ultimately accomplished. But owing to the persistence of "subject-predicate" modes of thought these inconsistent elements were swept aside in favour of the consistent if sterile sensationalism (*Process and Reality*, pp. 78, 182 *et seq.*, etc.). But to their contemporaries this apparent success in the smashing of the ancient idols seemed to open the way for clear thought and undimmed vision of things as they are. That this very effort to see and think on such things as truly exist constitutes not only the aim but also the most elusive problem of all philosophy the optimistic sceptics of the eighteenth

century failed to realize. When in place of the old idols they enthroned what they took to be the spirit of natural science, they conveniently forgot that the demonstration of the non-existence of matter—the then tacitly accepted basis of science—had been one of the links in the chain which had led them out of the darkness into the clear realms of free thought.

Nevertheless the sensualism and materialism of the eighteenth century cannot be ignored, for not only is its message still needed as a corrective against the too speculative character of all idealism, but it enunciated the truth that whatsoever may be the validity of science as representing the totality of the real, within its limitations, whatever they may be, its results are inescapable; and any philosophical system that seeks to ignore them is to that extent false. That the materialists of this period went too far in their claims for the completeness of their philosophy would now hardly be questioned; but that their influence was a powerful and valuable one has already been shown in the number of idealists who gave unqualified assent to the doctrine of the inviolability of natural law within the sphere of nature.

The twin roots of materialism lie in the work of Condillac on perception and de la Mettrie on materialism proper. The former was not in the strict sense a materialist, but sought to explain knowledge, thought, and memory by the ingenious figure of a marble statue endowed successively with the five senses which, he urged, were alone sufficient to account for the facts of consciousness. De la Mettrie equally denies the existence of any mind, the phenomena termed

mental being nothing more than the functioning of the brain. Everything, including man, exists and proceeds according to strictly determined natural law, and is ultimately reducible to the play of particles of matter in motion. Man differs no whit from any other machine except in his power of winding himself up. The internal weakness of this doctrine is shown up by de la Mettrie's exhortations to throw off restraint and indulge the senses. Yet does not this very power of *choice* distinguish man from all other machines, even from the beasts of the field?

These two doctrines were cast into a relatively systematic form by Holbach. "There are no unknown forces, but only attraction and repulsion, to which all process is referable, of which the causal relationship forms a closed and boundless system" (Eisler, *op. cit.*, p. 45).

This is the sort of philosophy that had to emerge from the new and far-extended triumph which the Demokritos–Lucretius nature philosophy gained by the work of Newton (codified in the famous scholium to the *Principia*). There above men's heads were the heavenly orbs for ever circling in predetermined paths; despite the clash of empires and the upturned faces of the Faithful the earth sweeps on, the tides wax and wane, the winds come and go, with lofty, cold indifference. It was a temptation too good to resist, namely, to generalize from this great proof of the unchangeable procession of matter, without first enquiring into the insidious unproved premises—insidious because so easily and unconsciously assumed—which lie at the basis of all physical speculation. Where the founder and author of this great synthesis feared to tread—"The great ocean of truth lay all

undiscovered before me"—lesser men rushed in with complete solutions of the riddle of the universe.

In the elaborate and far-reaching system of Haeckel we shall meet once again with this monistic materialism, but this time a much clarified materialism, founded negatively on the failure of the post-Kantian idealism, and backed positively by all the resources amassed by more than a century of active investigation in natural science. But before turning to a detailed consideration of this system we shall, in order to assess as justly as may be the influences which determined the life and thought of Haeckel, consider briefly in this chapter the main trends of thought in realistic philosophy, and in the Second Part, and at greater length, the stage of development of natural science, which enabled him to present materialism in so much richer apparel than had the French Illumination.

Among the realistic followers of Kant there were so many fine shades of opinion that it is wellnigh impossible to present a coherent picture of their contributions without plunging into a long and detailed comparison beyond the compass suited to this work. I shall therefore select a representative of each of the three or four main groups which I believe to have exercised most influence on the enlightened opinion of Haeckel's generation. We are in the further difficulty that the full weight of much of their thought has been felt, at any rate by men of science, only in the last few decades; their critical thought, and this is likely to be the most lasting of their contributions to knowledge, concerns us therefore more in the Third Part of this work, where a thorough investigation of the basis of natural science is to

be our task. The brief remarks made here, therefore, are to be accepted as in no sense attempting an adequate representation of the thought of these workers, but merely as indicating the changed point of view which began gradually to be evident among the realistically inclined.

Most prominent among the early followers of Kant to voice doubt concerning the ultimate validity of materialism, while remaining sympathetic with its use as a regulative principle in natural investigation, is F. A. Lange. He emphasizes the futility of attempting to "reduce" the physical to the psychical, or *vice versa*; what for the individual percipient is thought, is molecular movement for the external observer; and this is ultimate. Each is perfectly just in upholding his view as the only true one; indeed, for the external observer to assume the slightest deviation from the conservation or causation principles would be to fall from the pursuit of truth into mere self-deception. But so also would it be for the percipient subject to attempt to explain away his psychic states as "nothing but" the movements of "real" molecules. Matter, indeed, is merely "that which we are unable or unwilling to resolve into forces."

Materialism, then, in the literal sense is rejected by Lange, but the nature of these forces, which are the true properties of things, is left undetermined.

Attempts were soon forthcoming from philosophically minded men of science to give a more precise significance to these "forces." Of the physical group Ostwald may be taken as representative. He was not slow to realize the invaluable metaphysical basis which natural science had provided in

the demonstration of the conservation and interconvertibility of the various forms of energy. The more we examine natural processes of all kinds, the more we are driven to see in them the manifestations of this measurable basis of all activity. And whereas matter is inert unless stirred into movement, or (in its more complex configurations) into life itself, by energy, the latter requires no "substrate," but is capable of independent existence (*cf.*, however, the view of Poincaré, p. 324 *infra*). Scientific materialism, whether monistic and consequently atheistic, or dualistic in order to allow for deity, is therefore denied by Ostwald as vigorously as by Lange, but with perhaps somewhat less discretion, seeing that the substitution of one physical concept, energy, for another, matter, is always liable to end in a merely more refined dogmatism.

It was the danger of scientific positivism degenerating into a metaphysic, as dogmatic and ill-founded as the worst of those of the schools, that drove Kirchhoff, Mach, Pearson, and others into the promulgation of that form of epistemology known as "phenomenalism." None of these writers agrees with the others in the detailed working out of the principle, but they are at one in demanding for science recognition as a self-subsistent system of truth free from the trammels of "metaphysics," upon which they one and all in varying degree pour scorn. On the other hand, if science is not to be the handmaiden of speculative philosophy it cannot itself pretend to the ambitious calling of the latter. Of knowledge, other than that gained by empirical science, there is none; yet it must be equally admitted that the knowledge which science yields affords no explanation of reality, but

only a complete description thereof. What difference there can be between an "explanation" and a "complete description" was unfortunately left undetermined.

From the methodological point of view this teaching was of inestimable value to the further progress of science. The pronouncements of scientific investigators are good science only when they are kept strictly within the bounds of objective reference, and when neither coloured by the particular temperamental predilections of the investigator nor pressed into service for the explanation of matters beyond the range of the experimental evidence upon which they were based. So long as Darwin's masterly observations of the metamorphoses of the rock pigeon were used to prove the possibility of the evolution of individuals showing even less resemblance to the original stock than exists between species universally recognized as diverse, they remained superlatively good science; but when they, and facts of a similar kind, were used as an infallible "proof" of the impossibility of man's possession of an immortal soul, they, or the use made of them, became contemptibly bad philosophy. That the outspoken utterances of Mach and Pearson have drawn attention to this flagrant misuse of empirical data to the furthering of transcendental prejudice has been all to the good; but when we come to examine the other side of the shield, as we shall do in the Third Part of this work, we are less ready to accept their dicta.

To the failure of this school of thought, which by its teaching brought to a head the dangerous elements latent in Kant's critique, we owe the efforts that have recently been made to bring science and philosophy into that har-

monious state of co-operation which they enjoyed in the times of Descartes, Spinoza, and Leibniz.

Between the school of Ostwald, who accepted energy as the basis of reality, and the anti-metaphysical school of Mach and Pearson stands Spencer, who, while denying that knowledge is anything more than a system of symbols representing the unknowable absolute, is nevertheless important to our study as being, in Dr. Eisler's apt phrase, "the metaphysician of evolution." His system calls for no detailed study; its lack of adequate metaphysical grounding makes it, as a system, of only transitory interest; but to him must be given the credit of reviving, in terms of the newly discovered mechanism of biological evolution, that fruitful concept of eternal flux between integration and disintegration which Herakleitos had shown to characterize reality as a whole.

The rest of the nineteenth-century realists fall mainly into two groups: those who, following Lange, recognized that though the realistic attitude perhaps furnished the clearest, if at the same time a one-sided, view, and those who, in their eagerness to disclaim allegiance to any entities beyond immediate sense experience, be they deity, spirit, or devil, erected in their stead the fetishes of Nature, ether-souls and the like, and this accompanied by much tub-thumping and the usual mumbo-jumbo of "science" in the puffed-up condition into which it so readily relapses as soon as it uncritically passes beyond the restricted realms to which its findings are alone relevant. Needless to say it is seldom men of science themselves who are responsible for these naturalistic orgies.

We have now said enough to indicate the welter of opinion in which lived and studied and strove the subject of our next full-length portrait, Ernst Haeckel. Our next task is to pass rapidly in review the essential aspects of the historical development of those scientific facts and concepts upon which his system was built. This enquiry, which will occupy the whole of the Third Part of this work, will at the same time enable us to take the first step towards the achievement of our ultimate task, which is to assess the monistic tendencies in modern science.

PART II

THE MONISTIC TENDENCIES IN SCIENCE DOWN TO THE END OF THE NINETEENTH CENTURY

CHAPTER X

THE UNITY OF MATTER

"This terror, then, and darkness of mind must be dispelled not by the rays of the sun and glittering shafts of day, but by the aspect and the law of nature; whose first principle we shall begin by thus stating, nothing is ever gotten out of nothing by divine power" (Lucretius, *De Rerum Natura*, English trans. by H. A. J. Munro, p. 5).

"A thing therefore never returns to nothing, but all things after disruption go back into the first bodies of matter. . . . None of the things, therefore, which seem to be lost is utterly lost, since nature replenishes one thing out of another, and does not suffer anything to be begotten, before she has been recruited by the death of some other" (Lucretius, *op. cit.*, p. 9).

"Then again we perceive the different smells of things, yet never see them coming to our nostrils. . . ." "Again, clothes hung up on a shore which waves break upon become moist, and then get dry if spread out in the sun. Yet it has not been seen in what way the moisture of water has sunk into them nor again in what way this has been dispelled by heat. The moisture therefore is dispersed into small particles which the eyes are quite unable to see. . . ." "Nature, therefore, works by unseen bodies" (Lucretius, *op. cit.*, pp. 10–11).

In the above extracts from the immortal work of Lucretius are summarized the creed and the implied ambition of

science. In nature all is in ceaseless flux and change, yet nothing is ever wholly lost but only transformed. In this flux nothing is called into being except from pre-existing materials; nor does anything new arise, nor is the course of anything changed by the fiat of a capricious god, but all proceeds according to the unalterable determination which is in the nature of things themselves. And the course of this change is in the main a continuous uniform interaction, which proceeds at all times without our being aware of it. In the explanation of nature we are to eschew all reference to causes except such as can themselves be related to known causes. In a word, the task of science is to account for the whole sensible universe in terms of the categories of the conservation of substance, and of uniform and necessary causation. How far this may be possible, and to what extent such an "account" represents the sum total of reality, we are not for the moment concerned with.

Now our object in going back to Lucretius for a definition of the "scientific" attitude is to show that this attitude is to a large extent intuitive. Of the regularity of causation, or natural law, there was in the observed behaviour of the heavenly bodies and in the orderly variety and adaptation of living things considerable evidence; but of the conservation of the material of which these objects consisted there was virtually none. Centuries before the only test that we know of—appeal to the balance—had, we may believe, been even thought of, mankind had become firmly convinced of the conservation of matter. It is true that both Lucretius and his predecessors had but a hazy notion of what was to be accounted as matter, inasmuch as by some

air was left out, and by Lucretius himself heat and cold were included; but stuff of some kind was the "first beginnings" of things, and this stuff was uncreatable and indestructible.

The whole tenor of these passages from Lucretius is to the effect that to reveal the *cause* of a change in nature is virtually to show that no *true* change has occurred: that, in fact, the same amounts of the same kinds of "stuffs" are present at the end as were at the beginning, but that a new set of relations has brought forth a new set of properties. That this same view of causality has been tacitly adopted in every great scientific advance is argued with great persuasiveness and a wealth of historical detail by Emile Meyerson in his *Identity and Reality*. "We prove," he writes, ". . . that science attempts equally to *explain* phenomena, and that this explanation consists in the identification of the antecedent and the consequent" (*Identity and Reality*, Author's Preface, p. 10).

Guided by this principle I shall hope to show in this part of the present work that science has not only tended to identify explanation with the conservation of a finite quantity and number of kinds of stuffs, but has tacitly assumed that *complete* explanation involves the reduction of these "stuffs" to one. I am not in this part concerned with the question of the validity of any such assumption.

And so first in regard to matter. The problem of the elements, their number, persistence, and interaction is conveniently described as the problem of matter, whatever view we may ultimately come to take of this now broken reed.

The science of matter is chemistry; and for our purpose

chemistry starts with the writings of the Arabian Jabir who flourished about A.D. 776. He gave to the somewhat vague speculations of the Alexandrian Zozimos and others a precision which caused these views to exert a not entirely beneficial influence on the progress of alchemy for about nine centuries. It is at present impossible to determine with certainty to what extent the Latin works of "Geber," which first became current in the fourteenth century, are translations of Jabir's own work, and to what extent they represent the maturer view of that later period (W. C. D. Dampier-Whetham, *History of Science*, 2nd edn., 1930, p. 79); but for our purpose it is of no importance. What does concern us, however, is that the Neo-Platonic belief in one substance, whose qualities may be altered by suitable reagents, is in these writings being tacitly called in question. The basis of matter, or more strictly metals, since these were the main interest among the alchemists, is twofold, namely, mercury and sulphur. That the Neo-Platonic attitude is still operative is seen in the fuller explanation given by the alchemists of these terms; for neither is to be understood as connoting any natural substance, but some principle or essence which determines the quality of its products, the "mercury" giving lustre, permanence, fusibility, and the like; "sulphur" being responsible for that quality of baseness represented by combustibility.

This theory has been the object of ridicule and contempt, but unjustly so; for it represents the first attempt to frame a working hypothesis whereby actual substances might be studied in the light of a philosophy which believed in the unity of nature. Science is here very much the slave

of philosophy (only later was this study turned to the uses of avarice and charlatanry), and remained so until it had recognized that to attain to even relative truth it must refrain from mixing the necessarily vague concepts of philosophy with the clear data experiment can yield, replacing the former by *verae causae* taken from the realm of the immediately known. Naturally enough, as soon as this step was taken the number of mutually irreducible elements began to increase rapidly.

The crucial step of sweeping away all "principles" and "essences" about which, if they indeed exist, the operations of chemistry can tell us nothing, and of clearly defining an element as some residue *which experience shows* cannot *so far as experience goes* be resolved into anything other than itself, was taken by Robert Boyle about the middle of the seventeenth century: "[I] must not look upon anybody as a true principle or element, but as yet compounded, which is not perfectly homogeneous, but is further resoluble into any number of distinct substances how small soever. And as for the chymists calling a body salt, or sulphur, or mercury, upon pretence that the principle of the same name is predominant in it, that in itself is an acknowledgment of what I contend for; namely, that these productions of the fire are yet compounded bodies" (Robert Boyle, *The Sceptical Chymist*, Everyman Library, p. 131). But Boyle's criticism was not only negative, for, although he played no part in the subsequent discovery of the chemical elements, he drew attention to the fact that not matter alone, even in the form of several irreducible factors, can account for the variety of materials present in the world.

But, granted the differentiating power of figure and motion, wonderful variety may indeed be derived from but one substance. "To show how slight a variation of textures without addition of new ingredients may procure a parcel of matter divers names, and make it be lookt upon as different things: I shall invite you to observe with me, that clouds, rain, hail, snow, frost, and ice may be but water having its parts varyed as to their size and distance in respect of each other, and as to motion and rest. And among artificial productions we may take notice . . . particularly of the sugar of lead, which though made of that insipid metal and sowre salt of vinegar, has in it a sweetness surpassing that of common sugar, and divers other qualities, which being not to be found in either of its two ingredients, must be confessed to belong to the concrete itself, upon the account of its texture" (Robert Boyle, *op. cit.*, p. 203). In the two instances above quoted Boyle clearly recognized, though he did not distinguish between them, the possibility of physical action, whereby the same pure element or compound may appear in a variety of forms according to the mutual relations of its homogeneous particles, and chemical action whereby through the more intimate association of the particles of two or more elements new properties may arise which could not have been foretold by any previous investigation of those elements, however thorough. This is an extended form of atomism, as Boyle himself admits (*op. cit.*, p. 119). Unfortunately in reviving this most fertile of the physical conceptions of the Greeks he fell into the error of postulating an atomic, hence material, constitution for fire; a view which was largely responsible for the long

period which supervened before chemists began thoroughly to apply the valid principles he had laid down.

The reign of "phlogistonism," beginning with the publication of Becher's *Physica Subterranea*, in 1669, and ending within a few years of the publication of Lavoisier's famous paper in 1775, forms one of the most remarkable chapters in the history of chemistry. In the attempt to correlate the various kinds of combustion the phlogistonists made the second great advance in the history of chemical theory; it is only the stubborn refusal to recognize the falsity of their postulates which calls down the just censure of subsequent generations. Becher's three "earths" (mercurial, vitreous, and combustible or *terra pinguis*) are evidently modifications of the Paracelsian *tria prima* to meet the particular problem of combustion then engaging the attention of chemists (*cf.* E. v. Meyer, *History of Chemistry*, 2nd English edn., 1898, p. 110). Stahl, however, was more imbued with the new scientific spirit exemplified by Boyle. Seeing that in common combustion something appeared to escape in the form of a flame, and that in the calcination of metals heat and light were likewise produced, even if no flame were recognizable, he felt himself justified in postulating some fiery *principle* of a distinct character, which he named phlogiston, though according to Dr. J. H. White he did not in fact originate but only more clearly define the term (*The Phlogiston Theory*, p. 51). With great acumen and experimental exactitude he proceeded to show that carbon[1]

[1] In the sense only that carbon matter was associated with a maximum of phlogiston, which is not fire particles but only their *motus* (White, *op. cit.*, pp. 55–6).

must approximate closely to pure phlogiston, in that it not only disappeared almost completely on combustion, but if heated with a calx, that is a dephlogisticated metal, it yielded once again the metal. Similar explanations were found to be applicable to the facts of respiration and decomposition of organic matter. Seeing that "pneumatic chemistry" was only in its infancy we can hardly blame Stahl for not recognizing the production of a second substance (carbon monoxide) in the rephlogistication of the calx, nor for having failed to distinguish between the material (gaseous) character of the flame and the immaterial product of combustion (energy) which is contributed as much (and as little) by the unrecognized component (oxygen) of the reaction as by the combustible substance. After Lavoisier's classical work (the nature of which is too well known to need recording here) had demonstrated the necessity for a second substance before combustion can occur, the energetic aspect was for long overlooked; and it is only in comparatively recent years, since in fact the rise of physical chemistry, that it has been realized that the phlogistonists had obscurely glimpsed that other (non-material) aspect of chemical change which plays so important a part to-day. The obscurity of their vision was due to the imperfect definition of the nature of matter, namely, of the ponderable, however tenuous and impalpable, a definition for which the Edinburgh physician, Joseph Black, was mainly responsible.

It was inevitable that at the beginning of the nineteenth century, when the ground had been cleared of agelong confusions and prejudiced obsessions, matter should seem

to have become a plurality of substances, which although comparatively few, and capable by means of one simple causal schema (John Dalton, *New System of Chemical Philosophy*, 1808–10) of joining together to form the multitude of diverse materials which fill the inorganic world, were nevertheless ultimate *per se*. Moreover, the materials constituting organic nature were held to be formed only by the intervention of some "vital force." Though this gratuitous hypothesis was swept away in 1828 by Wöhler's synthesis of urea, yet by the invention and perfection of new methods (*e.g.* electric current, spectroscope, etc.) the number of unresolvable elements steadily increased until at the end of the century they numbered about seventy. It is true that man's intuition of a monistic basis of matter had survived the apparent denial of its possibility, for in 1815 appeared the first of two papers by Prout in which that author on the flimsiest evidence put forward the view that since the atomic weights were integral multiples of the atomic weight of hydrogen, the elements themselves must be relatively stable condensations of hydrogen. The influence which this paper exerted, unsupported by any adequate quantitative data, goes to show once again that man cannot rest satisfied except by a monistic interpretation of nature. Fortunately for the science of chemistry and unfortunately for Prout, the refinement of experimental technique in the determination of atomic weights introduced by Berzelius, Dumas, Stas, and others established values for the atomic weights of such elements as chlorine, copper, and barium, which left no alternative but to reject Prout's "law." On the other hand, although there existed

enough quantitative exceptions to render Prout's hypothesis sterile, the qualitative evidence implicit in the "law of octaves" of Newlands, the "triads" of Döbereiner, and finally the periodic "law" of Mendeljeff and Lothar Meyer revived considerable interest in his speculations; indeed, interest had never really died. The remarks of Marignac on the destructive criticism by Stas are of great interest. Moreover, Faraday, Maxwell, and others had all envisaged a possible disruption of elements or atoms (*vide* Alembic Club Reprint No. 2, Introduction and especially p. 58). Chief among these "chemical evolutionists" was Crookes, who, recognizing that the quantitative considerations above alluded to precluded the postulation of hydrogen as the primordial element, suggested some as yet undiscovered substance, which following the precedent of the Ionian monists he called "protyle" (*Journal of the Chemical Society*, London, 1888 and 1889). He based his views not only on the periodic repetition of properties at regular intervals in the scale of atomic weights, but also on his own observations of the striking similarities in the spectra of the rare earths. Similar speculations on the evolution of the elements by the condensation by cooling of a primordial fluid element were put forward by Tilden and Preyer at a time when the spectroscope had already shown that in all probability the whole universe is composed of the same elements as is the earth, though different stars do not all contain the same elements.

The difficulties in the way of acceptance of these views at the time when they were put forward were in the main three, namely, that the *protyle* itself was purely hypothetical;

that its condensation and association into relatively unresolvable aggregates was not a *vera causa*, no such process ever having been observed; and finally that the "law" (*i.e.* the periodic system) upon which they were based, although much more comprehensive and fertile in its applications, was no more a law of nature than Prout's. Indeed, the number of inexplicable contradictions of various kinds (*e.g.* the position of hydrogen, the false position of iodine and tellurium, the anomaly of the rare earths) rendered Mendeljeff's even further from being a law than was Prout's. At the end of the nineteenth century, then, the πρωτή ὑλή of the ancients was as much a speculation as ever; man's philosophy might drive him to seek one material substance only at the basis of the many his senses revealed to him, but his science, so far from narrowing down the search, delighted to honour the discoverer of each addition to the threescore-and-ten material elements already known!

CHAPTER XI

THE UNITY OF NATURAL FORCES

§ I. Inertia, Gravitation, and *Vis Viva*

If in the realm of matter science persisted in yielding evidence of a plurality of substances, in the study of the variety of forces which drive matter through space and bring to it the life-giving influence of light and warmth it was far otherwise.

By the end of the seventeenth century the essential characteristic of matter—inertia—was fully recognized and its consequences fully developed. Matter needed no prime mover; for since all known translatory motion was relative, rest was but a special case of motion. Still less did it need a persistent force to keep it in motion. Matter, in fact, was just matter in so far as it would go on doing what it was doing until some *external* influence compelled it to change its state of motion. But here a huge anomaly sprang up, which, however, was swallowed whole in the hurry to work out the consequences of the discovery, namely, that apart from the intervention of living creatures, the most common, and at all times the most potent, of these external forces was not wholly external but resided in matter itself. It was external in so far as a piece of matter external to the given system alone could alter the behaviour of that system; yet the effect when it did occur was caused as much by the matter of the system as by the external matter. This remarkable stuff, matter, then bears upon its face the stamp of

that illogical entity, mind, for while utterly impotent to direct its own affairs it is at the same time endowed with the power of influencing, maybe to a catastrophic extent, the affairs of other bits of matter.

The above is a somewhat fantastic but I believe accurate summary of the qualitative aspects of Newton's three laws of motion and his conception of gravitation. But it omits the quantitative relationships, the application of which proved that, whatever it was, or was not, in matter or outside, that makes two pieces of matter alter their previous states when approaching one another, in any case the effect is numerically the same whether it be an apple and an earth, or a sun and a planet. Later work, beginning with the discovery of the dark companion of Sirius by Alvan Clark in 1862 on the basis of Bessel's computation eighteen years previously of the elliptic elements of Sirius, has shown that the same law may be extended to the furthest confines of space.

The behaviour of matter, then, could be predicted in theory (the mathematical difficulties become almost impossibly great for more than three bodies) provided only that the inertia (mass) was known, and the position of the bodies with regard to space and time axes. Mass is, of course, the numerical coefficient which is put in the dynamical equations to make then "true." Its definition by Newton as "quantity of matter" (= volume × density) is, of course, circular (*cf.* Poincaré, *Science and Hypothesis*, p. 103). The "behaviour" that is thus predictable is, in fact, nothing else than a new set of relationships to the same axes of space and time, the importance of the discovery being that *all* matter, whatsoever its colour, shape, and chemical

properties, behaves in precisely the same way towards any other matter whatsoever. Matter, then, is a pure, simple concept with respect to "force"; for although there may be several kinds of ultimate substances in respect of those changes we call "chemical," there is virtually but one in respect of those we call "mechanical."

What, then, is this "force" which "causes" the motion, or rather change of motion, of matter? Reference to any one of the classical textbooks on mechanics will surely enlighten us. Thus Whewell: "Force is any cause which moves or tends to move a body, or which changes or tends to change its motion" (*An Elementary Treatise on Mechanics*, 7th edn., 1847). This does not at first appear very helpful; definitions seldom are; but Whewell goes on to explain that when we become aware of a change of motion in a body we find it helpful to say that a force is acting on it. In other words, force is one of the few remaining "spirits" left over from the Neo-Platonic fairyland (*cf.* Poincaré, "When we say force is the cause of motion we are talking metaphysics," *op. cit.*, p. 98). It has survived because it can be applied quantitatively; it has, indeed, in the hands of Newton, Lagrange, Laplace, and many others, served the scientific edifice as perhaps no other instrument has. Its very success however, gave it a kind of reality which it does not possess, with the result that, as we shall see later, it and other learned catchwords, such as natural selection, turned the Europe of the nineteenth century into a bear-garden of untamed scientific sophists.

Once again, then, we affirm that there reside in matter of every kind and in every place two qualities, namely,

inertia and gravitation. Later we shall have to enquire more precisely into the meaning of these three terms in the light of recent discoveries, and we shall find that they are by no means ultimate; but the above statement summarizes all that the great pioneers of the seventeenth century discovered that is pertinent to our present enquiry; nor had it been modified up to the close of the nineteenth century.

One other concept, however, which is of the utmost consequence to our discussion, needs to be mentioned. We have already seen that Descartes based his cosmology on the principle of conservation of the total quantity of motion. As against this Leibniz contested that a quantity which he termed *vis viva* is what is conserved. For about half a century the mathematical army of Europe was split into warring factions disputing as to which of these quantities, namely, that which is proportional to velocity or that which is proportional to the square of the velocity, is the more fundamental. After a searching enquiry D'Alembert showed that in one respect the dissension was merely verbal, having arisen out of a failure on the part of Galileo and his contemporaries to define their terms; on the other hand, since what is sought is an expression for the capacity of a moving body to do mechanical work, and since work is normally regarded as the product of the force and its displacement, that function of force which is expressed in terms of displacement (*i.e.* the function which varies as the square of the velocity) is the correct one, and not that in which the magnitude of the force is expressed as a function of time. This principle of the conservation of *vis viva* (which in the units usually employed is equal numerically to the product

of half the mass and the velocity squared) became henceforth the basis of mechanics, and together with the more complex principle of least action raised the science to the status of a special branch of pure mathematical analysis.

§ 2. The Imponderable Fluids

During the seventeenth century began, or was revived, the study of nearly all the other forces of nature, namely, sound, heat, light, magnetism, and static electricity. The true nature of sound as being merely the sensation caused by the rapid to-and-fro impacts of the particles of air on a delicate membrane had been correctly surmised by Vitruvius in the first century of our era. He had even gone so far as to compare the propagation of sound with that of waves on the surface of water; but he gave no sort of proof of the correctness of this view. The experiments of Mersenne, Noble and Piggott, Wallis, and others had from various points of view established the general correctness of the hypothesis; but it was Newton who removed any remaining doubt. He showed that on the basis of Boyle's law of the bulk elasticity of gases the velocity of a sound pulse in air must be equal to the square root of the ratio of pressure to density, provided the temperature remains constant. On putting this relationship to experimental test in the quadrangle of Trinity College, Cambridge, he was disappointed to find that the result, although of the right order, was larger than the calculated value by an amount too great to be accounted for by any error of measurement. Nearly a century later Laplace showed that there was no

error in Newton's argument so far as the mechanism of propagation was concerned, but merely that the latter had incorrectly assumed that the heat evolved during the compression phase would have time to be dissipated into the surrounding medium. On applying a simple correction, Laplace found Newton's formula fully adequate to the facts.

Sound, then, differs not at all from any other motion of matter save that it is periodic, and that there exist in the higher animals organs which are sensitive to periodic disturbances of certain frequencies. It has been amply demonstrated that the upper and lower limits are not the same for different organisms; hence what is "sound" for one may be, unless the centre of disturbance is seen, non-existent for another.

With the remaining forces of nature, however, the seventeenth-century investigators were less fortunate; for though much valuable work was done, in no case was the nature of the "force" correctly established. The several theories of the so-called magnetic and electric "fluids," and of the thermal and luminous "substances," follow such devious lines in their development that it will be convenient to trace them separately, it being understood that however tempted we might be to search out and examine every source of the main stream of thought, we must restrict our discussion to the barest outline, but choosing those features which seem best to shed light on the problem of the unity of nature, omitting it may be experimental work of a high order which is not immediately pertinent to our subject.

§ 3. Heat

Perhaps owing to the accompaniment of heat in common combustion by visible and, maybe, tangible, and ponderable phenomena, the study of heat was for a long time treated as a branch of chemistry. Doubtless, also, men's minds were obsessed by the placing of heat by Aristotle on a par with air, water, and earth—all ponderable substances—even long after Boyle had clearly demonstrated the falsity of regarding these as "elements." We have already seen (p. 176) that Boyle himself was partly responsible for this failure to distinguish between the movement of ordinary material particles and the movement of the particles of some hypothetical substance, heat itself. (Hooke's opinions were much less confused: "Heat [is] nothing else but a very brisk and vehement agitation of the parts of a body." *Micrographia*, quoted by H. Buckley, *A Short History of Physics*, London, 1927.) The success of the phlogiston theory in chemistry and the widespread prejudice against undulatory theories in general during the eighteenth century so firmly established the belief in a separate thermal substance that the very man who demonstrated the wrong-headedness of the phlogiston theory as regards chemistry (Lavoisier) introduced the term "caloric" to designate the thermal fluid (though he admitted that it be only a "repulsive effect" and not a real substance; Buckley, *op. cit.*, p. 128). It is interesting to note how the theory of caloric repeated in a measure the successes and blunders of the phlogiston theory. As Sir W. Dampier-Whetham has pointed out, in the eighteenth century "the advances which were waiting to be made needed the idea of heat as a measurable quantity, unchanged

in amount as it passed by contact from one body to another. . . . This was at hand in the theory that heat was a subtle, invisible, weightless fluid . . ." (*op. cit.*, p. 221). Better, indeed, a wrong hypothesis than none at all. When the right hypothesis was the fashionable one, little advance was made in the study of heat; with the wrong but more tractable one, Black, Dalton, Gay-Lussac, Fourier, and, *mirabile dictu*, Carnot laid the foundations of all branches of the science of heat other than that of radiation. But although the findings of Fourier and Carnot were both expressed in terms of caloric, whereas the demonstration of the former, that the law of flow of heat along a temperature gradient is mathematically identical with that of the flow of a material fluid along a gravitational potential gradient, was the greatest triumph of the caloric theory, the work of Carnot, in so far as it implied that the power of heat to perform work is independent of the substance it is associated with, and dependent only on the temperature relations, contained the germ of the theory's destruction. Nevertheless the theory might have persisted indefinitely, accepted as it was by such leaders of thought as Kelvin, who went so far as to say (1848) that "the conversion of heat or caloric into mechanical effect is probably impossible, certainly undiscovered" (quoted by Buckley, *op. cit.*, p. 145), had it not been attacked from two different standpoints, namely, experimental and analytical. The former was initiated by Rumford, who showed that an apparently infinite quantity of heat could be obtained by friction from a finite quantity of metal without thereby altering either the mass or the capacity for heat of the latter. Davy completed the qualita-

tive overthrow of the caloric theory by melting two insulated blocks of ice by friction against one another (1799). Although the theory, as we have seen, refused to die, its end was hastened by a long series of experiments by Joule, in which he showed that the quantity of heat produced bears always a fixed ratio to the mechanical work done, howsoever it may be done.

From the analytical point of view it was attacked by Mayer. His work is of outstanding importance to our general problem, in that he had no experimental basis to work upon, save Dulong's demonstration that the heat evolved on compressing a gas is *proportional* to the work done. Mayer assumed as axiomatic its *equivalence*, since an experiment of Gay-Lussac had shown (it was, of course, later found to be incorrect) that no work is done against the mutual attractions of the molecules. And not only with heat, but with all natural forces, did Mayer equate mechanical work; thus intuitively asserting on the metaphysical basis of the imperishability of substance, the principle of "conservation of force," some years before it was experimentally grounded. The principle was also put forward by Helmholtz as a result of an exhaustive examination of mechanical operations, including the collision of inelastic bodies in which force had been held to be destroyed. He admitted that the complete corroboration of the principle, so far from being contained in his analysis, was rather to be the stimulus to investigation in every department of physics; the significant feature of his demonstration being the linking up of the new conception of energy with the quantitative one of *vis viva*.

At this stage one problem alone prevented the complete

replacement of the caloric theory by the mechanical energy theory, this being the apparent contradiction between Joule's law and the findings of Carnot, which latter, as we have seen, was readily explicable in terms of caloric. This last stumbling-block was removed simultaneously by Kelvin and Clausius, who now showed that it needed only that a clear distinction be drawn between total and free energy.

By 1851, then, the caloric theory had been given up, but as yet no very clear idea had been put forward as to what heat actually is. This defect was rectified by Clausius in 1857 when, in a paper entitled "Ueber die Art der Bewegung, welche wir Wärme nennen," he extended the kinetic theory of gases put forward by Daniel Bernoulli, Waterston, Joule, and others, to include the postulate that the temperature of a gas is a measure of the mean kinetic energy of its molecules. This happy thought rendered comparatively simple the explanation of all the common thermal phenomena (*e.g.* latent heat, expansion, constancy of vapour pressure at constant temperature, etc.) in purely mechanical terms. Like sound, heat now becomes merely the sensation of rapid motion of the particles of matter, but a motion having no periodic character in the mass as is the case with sound.

Thus far, then, the hypothesis was in full qualitative agreement with the facts. Within three years of the appearance of Clausius's first paper there commenced that wonderful statistical treatment of the problem by Maxwell from which developed in every direction those quantitative verifications which have placed the kinetic theory of heat and matter, jointly with the molecular and atomic theories, among those permanent verities headed by the law of gravitation.

§ 4. Light

Although the three basic laws of geometrical optics—rectilinear propagation, reflection, and refraction—had been correctly demonstrated before Newton was born, nothing approaching an adequate hypothesis as to the nature and action of light had been put forward. In 1690, however, appeared Huygen's *Traité de la Lumière,* and in 1704 the first edition of Newton's *Opticks.* These two works not only contain nearly all the fundamental facts concerning the properties of light, but between them indicate the kind of model upon which all subsequent theories of light have been based. That light was subject to strictly mechanical treatment had been made manifest by Roemer's proof of the finite velocity of its propagation. It was naturally assumed that any influence thus characterized must be associated with something movable. Whereas Newton supposed that the motion was one of the translation of corpuscular bodies—"Are not the Rays of Light very small Bodies emitted from shining substances?" (Query 29, *Opticks,* 4th edn., 1730)—Huygens restricted the motion to a periodic displacement of an elastic fluid in a direction at right angles to the plane of the advancing wave. We are not here concerned with a discussion of the reason for the temporary victory of Newton's view, which lasted, indeed, for a century, but it is only fair to point out what has frequently not been made clear, that Newton himself expressly states: "In this third Book I have only begun the Analysis of what remains to be discover'd about Light and its Effects upon the Frame of Nature, hinting several things about it, and leaving the Hints to be examin'd and

improv'd by the further Experiments and Observations of such as are inquisitive." We are then quite unjustified in regarding the corpuscular theory as being anything more in Newton's eyes than the best hypothesis available, but by no means to be accepted as proved. He did, indeed, do rather less than justice to the alternative view of Huygens, concerning which he was guided in his judgment by the difficulty of imagining how by "Pression or Motion" light could be "propagated in a Fluid in right lines, beyond an Obstacle which stops part of the Motion" without bending and spreading "every way into the quiescent Medium which lies beyond the obstacle." But Huygens had shown that the difficulty could be overcome; and if it be urged that his explanation is somewhat artificial, why so surely is Newton's theory of fits of easy reflection and transmission?

Setting aside the queries in which Newton is concerned to denounce the rival theory we may rather be astonished at the completeness with which Newton's expression of the facts (as distinct from attempts to explain them) foreshadow the undulatory theory in the form it was ultimately to take. Thus he recognizes that a beam of light possesses a periodic property (call it what you will) returning at regular intervals in space (*i.e.* thickness of plate), which, since the velocity of light is constant, involves regular succession in time; further, that light has a vector property ("Have not the Rays of Light several sides endued with several original properties?"—*Opticks*, Query 26, p. 333); that it has a vibratory cause ("Do not all fix'd Bodies, when heated beyond a certain degree, emit Light and shine; and is not this Emission performed by the vibrating

motions of their parts?"—*op. cit.*, Query 8, p. 314), and that it is intimately associated with, if not actually caused by, "the Vibrations of a much subtiler Medium than Air" (*op. cit.*, Query 18, p. 323), and that this medium is the same as that by which heat leaves a body suspended in a vacuum. (For a fuller discussion of the whole matter in another connection, *vide infra*, p. 276 *et seq.*)

About a century passed during which the study of light was almost at a standstill. Interest was reawakened when Thomas Young and Augustin Fresnel independently repeated Newton's experiments on the fringes seen in the shadows of small objects and discovered the principle of interference. It seems most likely that in the case of Young at least his experimental investigations were prompted by an intuitive belief in the existence of a luminiferous ether, this hypothesis being the only one which would account for the similarities between light and sound. Although the interference principle rapidly strengthened the position of the wave theory, in that exact measurements of wave-length were thereby rendered possible, the latter theory was still powerless to explain double refraction and polarization. As a result of his studies in the theory of elasticity, Young had shown that it is possible for a wave disturbance to occur in the plane of the wave front; if this were so in the case of light, then polarization could be readily explained as the configuration of the polarizing substance being such as to allow disturbances, or the components of disturbances, parallel to one axis only, to pass through. The hypothesis was the only one which could explain the experiments of Fresnel and Arago, in which it had been shown that two

rays polarized in the same plane interfere normally, but if polarized in perpendicular planes, not at all. Fresnel had himself considered the possibility of this hypothesis, but had rejected it owing to the necessity thereto enjoined of attributing to the luminiferous ether the properties of a rigid elastic solid. On receiving Young's letter, however, he dismissed the objection as for the present irrelevant, and within a few years he had completed that masterly system in which all the known phenomena of light could be precisely interpreted in terms of a single vibrating medium.

The development of spectroscopy during the years following this great synthesis brought two other sets of phenomena within the compass of the same generalization, namely, the radiation beyond the violet, which though invisible excited fluorescence and affected salts of silver; and also that beyond the red, which, alike invisible, could be detected by delicate thermometers. Stokes showed that the former were rays of too high a frequency to produce the sensation of light, but could easily be "degraded" into the visible range by means of fluorescent and phosphorescent substances. As regards the infra-red, Draper demonstrated their perfect continuity with the visible band, the temperature of the emitting substance determining the character of the radiation. The infra-red rays were also shown to be capable of reflection, refraction, and even polarization.

The physical uniformity of all the known kinds of radiation was now established, but attempts to frame an explanation of the phenomena in terms of the properties of matter contained in the laws of dynamics were less satisfactory. Later we shall show reason to believe that any such attempt

is merely to seek to establish a contradiction. One important result did, however, arise in this connection. This was the demonstration by Foucault of the greater velocity of light in air than in water, which is in harmony with the undulatory theory but in radical contradiction to the gravitating-corpuscle theory (but see p. 279 *et seq. infra*). This does not, as has sometimes been stated, "prove" the correctness of the former; it merely proves the untenability of the latter, an important if incomplete advance.

§ 5. Magnetism and Electricity

At the end of the eighteenth century these formed two distinct sciences, the electric fluid being regarded as having nothing in common with the magnetic. In fact, matters were even worse, for the general opinion was that there were two electric fluids; though this may perhaps have been held as a convenient mathematical fiction after the demonstration by Franklin that whenever a quantity of vitreous electricity was created a like quantity of resinous came into existence simultaneously. However, in 1790 a kind of electricity was discovered which for many years was considered to be fundamentally different from the electric fluid of charged bodies. (Indeed in 1920 I heard a competent dental surgeon arguing as to whether the currents set up between a stopping and the inserted instrument were Galvanic or Voltaic!) In fact the first overtures, so to speak, were made not between the two kinds of electricities, but between "Voltaic" electricity and magnetisim. In 1820 Oersted performed the experiment of moving a suspended magnet by means of an adjacent current-bearing conductor, which

was to set alight so great a fire of enthusiasm as within a short time to revolutionize the life of the whole civilized world. If a current can in the absence of any magnetic material (shown by the power of two current-bearing helices to attract or repel one another, or separately a piece of iron) create a magnetic field, why, thought Faraday, cannot the reverse be brought about? After fruitlessly searching for the production of a steady current in the presence of a magnetic field he at last discovered in 1831 the fact that only when the magnetic field is changing is a current produced, and that the potential difference is proportional to the rate of change. The same "prince of experimenters" in the following two years showed that the electricities drawn from whatsoever sources are identical; and that chemical decomposition in solution is in precise ratio to the quantity of the current and to the chemical equivalents, which shows, as Helmholtz said, that "if we accept the hypothesis that the elementary substances are composed of atoms, we cannot avoid concluding that electricity also is divided into definite elementary portions which behave like atoms of electricity." Some ten years previously Ampère had shown that there is a definite mechanical reaction between a current and a magnet, and also between two neighbouring currents; and further that there is a strict proportionality between the strength of the current and the magnitude of the force (the usual vectorial methods of comparing forces being applicable).

It thus appeared that magnetism, electricity, and matter in its chemical relationships, though not necessarily one entity, nor interchangeable, have at any rate some fundamental common ground.

Great as was the importance of this synthesis, a greater, from the philosophical point of view, was yet to come. Faraday indeed seems to have been actuated throughout by a passion for uniformity; consequently he spent years in searching for some reaction between magnetism and light; he was at last successful in rotating the plane of polarization by means of a very powerful magnetic field; but the result remained an isolated fact. The ground was prepared for the complete synthesis by a long series of experiments which were probably not connected with it in Faraday's mind; these were undertaken with the object of gaining a thorough understanding of electrostatic induction. As a result of these Faraday was able to announce that fact upon which the greater part of modern physics is built, namely, that the seat of electric charge lies not on the conductors but in the dielectric separating them; further, that a thorough understanding of the distribution of this strain can be arrived at only by picturing it as acting along tubes as if it had the nature of an elastic fluid, but a fluid which by its power of repelling its neighbouring parts could exert its tension as it were "round corners." The same he held to be true, though with less conviction, for magnetic forces. There is implicit therefore in Faraday's theory of electricity and magnetism the belief that they consist of directed stresses in a universal medium. Actually, as a result perhaps of the widespread influence of the new atomic theory in chemistry, he expressed this view in terms of chains of "polarized" particles.

§ 6. Field Physics

Physical theories generally belong to one of two kinds; those framed upon the model of Newton's law of gravitation in which the reacting forces are conceived to consist of discrete particles acting at a distance from one another; and those, of which the undulatory theory of light was the first example, in which emphasis is transferred from the origin of the disturbance to the medium, or "field," in which it is supposed to be propagated.

Until 1864 the undulatory theory of light was the sole representative of the group of theories now known as "field physics," and even that was based on the supposed dynamic properties of a hypothetical fluid. But in that year Maxwell published the first of a series of papers, which, culminating in the *Treatise on Electricity and Magnetism* in 1873, showed that the propagation of light is only a special case of disturbance of an electric and magnetic character. He was inspired to this end by the work of Faraday on the essential part played by the dielectric, or field, in electrical as well as magnetic phenomena. Indeed, in a paper published in 1846, Faraday himself anticipated Maxwell's views by "proposing to dismiss the ether" and replace it by lines of force between centres, these centres *and their lines* constituting the particles of matter; this was evidently the beginning of the end of the long undisputed rule of action at a distance. Maxwell's own words on this are worth quoting: "Faraday, in his mind's eye, saw lines of force traversing all space where the mathematicians saw centres of force attracting at a distance. Faraday saw a medium where they saw nothing but distance. Faraday sought the

seat of the phenomena in real actions going on in the medium. They were satisfied that they had found it in a power of action at a distance impressed on the electric fluids" (Preface to *Treatise on Electricity and Magnetism*). But Faraday's words were unintelligible to most of his contemporaries until translated into mathematical symbols by Maxwell. To the strained condition of the dielectric between bodies Faraday had given the name "polarized state"; this Maxwell changed to "electric displacement," the fundamental notion in Maxwell's ultimate theory being that the reaction between charged bodies corresponds, as it were, to a current which is prevented from actual flow by the power of the dielectric to support the strain. Similarly Faraday's "electrotonic state," that state upon a *change* of which depended the induction of electromotive force in a neighbouring conductor, was called by Maxwell the "vector potential," and defined by him in terms of pure analysis; thus the rate of change of the vector potential determined the magnitude of the electromotive force induced.

The next step taken by Maxwell was to show that since the electric and magnetic fields are reciprocally related, a change in the electric displacement must spread throughout the medium in the form of a wave composed of a magnetic and electric component at right angles to one another and in the plane of the wave front. He then showed that the whole theory could be summarized in the form of three equations, which are merely special cases of the equations of Lagrange to which any dynamical law must conform. From these equations he deduced that the velocity of the wave must be approximately that of light.

Now Maxwell had all along guided his thoughts by express-

ing each concept in terms of the motion of an elastic fluid ether, but one having the power of rotation about any number of contiguous axes. When he discovered the velocity of the electro-magnetic disturbance to be that of light, he at once concluded that the ether in which the former disturbances were propagated must be the luminiferous ether, or, since the former is of higher generality than the latter, that light is merely the sensation produced by the impact on a sense organ of electro-magnetic waves belonging to a band of frequencies with both upper and lower limits; radiant heat corresponding to a band of lower frequencies, ultra-violet radiation to one of higher.

This, the greatest synthesis since Newton, more comprehensive than that of Fresnel, was given a cold reception save by a very few. This was not due solely to the unimaginativeness of contemporary *savants*, for not only was the theory a radical departure from conventional standpoints of proved worth, but intrinsically it supplied no clue as to the nature of electricity as such; nor was it backed by any experimental verifications. Its triumph came in a spectacular manner in 1887, when, eight years after Maxwell's tragically early death, Hertz detected by means of a simple resonator the production of electro-magnetic waves set up by an oscillating discharge at some distance from the resonator. With masterly technique, having shown that the spark passes in the resonator only at such positions as could be explained by the setting up of stationary waves by interference between the source and the walls of the room, he calculated the wave-length and caused the rays to be refracted and polarized.

Whatever it is, then, that is at the basis of light is also at

the basis of heat, electricity, and magnetism. Eight years later a new kind of radiation was discovered by Röntgen, which, though invisible, can, after traversing metal foil of thickness varying with the density of the metal, be degraded by chemical screens into visible light. The frequency of these rays was found to be considerably greater than that of the ultra-violet.

The monistic interpretation of natural forces had thus triumphed completely, save in one particular—gravitation. Gravitation, as if jealous for the reputation of its founder, remained gloriously aloof from the electro-magnetic field, and continued to act at immeasurably great distances in immeasurably small times. But gravitation pertains to matter in a more intimate way than does energy; and matter had definitely indicated its discrete character in so far as chemistry was concerned. The result, then, of the unification of physical forces seemed to be the driving of an impassable wedge between the world of energy and the world of matter; each was conserved after its own kind, but each was complete for itself. For the time being the once discredited ether, or *plenum*, got the upper hand, and attempts were made, as, for instance, by Kelvin, to construct a theory of matter on the properties of a rotating fluid. But the first bridge between energy and matter, between the continuous *plenum* and the void full of atoms, was built out from the opposite shore. At the close of the nineteenth century a new generation of physicists were exploring just those aspects of Faraday's work (on the association between electricity and material atoms) which Maxwell had quite consciously set on one side. But the development of these researches lies in the twentieth century.

CHAPTER XII

THE FACE OF NATURE

"In the beginning God created the heaven and the earth.

"And the earth was without form, and void; and darkness was upon the face of the deep. And the Spirit of God moved upon the face of the waters.

"And God said, Let there be light: and there was light.

". . . And the evening and the morning were the first day.

"And God said, Let the waters under the heaven be gathered together unto one place, and let the dry land appear: and it was so.

". . . And the evening and the morning were the third day.

"And God made two great lights; the greater light to rule the day, and the lesser light to rule the night: he made the stars also" (Gen. i. 1, 2, 3, 5, 9, 13, 16).

The above is a brief extract of the cosmogony which guided the science of geology until late in the eighteenth century. During the seventeenth century the biblical deluge was called in to assist in the interpretation of the organic remains which began to excite more and more attention. These had been correctly interpreted by such ancient writers as Xenophanes and Herodotus, but during the Middle Ages they were forced by Avicenna to fill a niche in the distorted Aristotelianism which governed all thought; this was done by stating that they were the failures of the

vis plastica, which is ever seeking within the earth to endue matter with form. The mocking laughter of Leonardo da Vinci failed to drive more than a few of his contemporaries from this wholly unjustifiable belief. Robert Hooke in the seventeenth century not only recognized the true nature of fossils, but urged that they represented historical evidence no less valuable than coins and monuments, for by comparing them with existing species, information might be adduced concerning the climate of their locality in bygone ages. The churches, seeming to realize that a compromise must be effected, here stepped in to claim all existing fossils, not indeed as *lusus naturae*, but as direct and incontrovertible evidence of the Flood.

When Newton's *Principia* was being hailed on all sides as the intellectual triumph of the age, William Whiston was writing his *Theory of the Earth*, which rapidly ran through six editions. Here is set out an account of the origin and history of our planet, and among many others includes the following details: that the diurnal rotation commenced only after the fall of man, after which there resulted an increased radiation of the internal heat towards the surface, encouraging a rich vegetation and growth of animal life, but also causing a strong development of human passions. Retribution came on November 18, 2349 B.C. [*sic!*] when the tail of a comet stood upon the earth shaking out water-spouts and causing the subterranean waters to burst forth and inundate its surface.

It is significant that the writer of the above imaginative work was recommended by Newton to succeed him as Lucasian Professor of Mathematics at Cambridge.

What has so far been written on the origin and development of the earth may perhaps be regarded as an irrelevant digression, but it was thought necessary to point out that science has from the first had to contend with the dualism of religious dogma, the dualism of a god who makes light before he makes any luminous bodies, and starts throwing comets about in order to destroy the pygmies of his own making, as a child will petulantly knock down a pile of bricks that will not perform impossible feats of equilibrium (*vide supra*, p. 203, quotation from Genesis. There is, of course, no question of belittling the theory of creation put forward by the priestly writer, which compared favourably with contemporary theories; what is deplored is the power of religious bodies to endow it two thousand years later with a scientific validity it cannot possess). And worst of all, so deep does the poison enter that a man who will carry out painstaking and accurate research in the laboratory or the field becomes, when standing before his fireplace, a pompous, prejudiced, and self-complacent dogmatist.

The science of geology, perhaps because it works on so vast a scale and attracts a number of industrious "lovers of nature" (and incidentally of sentimental generalizations) was the last to throw off the yoke of theocracy. The persistent refusal of its first great systematizer, Werner, to look facts in the face and admit the possibility of the igneous origin of the crystalline rocks can hardly be traced to any cause but a perhaps subconscious belief that the waters which covered the surface of the earth "were gathered together in one place" that the dry land might appear. Further, geology seems to have been a concretionary growth;

slabs of information have been added externally; guiding principles have been laid down in some directions, only to be ignored by other workers who have shed light on different problems. The difficulty has always been to find suitable means of verifying inductions and, perhaps more important, of disproving them. Wild tongues could announce fantastic cosmogonies, and no one could prove their falsity. So the game went on, with the result that by about 1770 someone or other had enunciated most of the fundamental principles of the science of geology and Kant had written (in 1755) his *Theorie des Himmels* in which he had step by step shown the possibility of accounting for the present arrangement of the heavenly bodies on strictly Newtonian principles; but the former lay hidden in a welter of error, and the latter was completely ignored. The precise and interrelated structures of physics and the speculative rubbish-heaps of geology seemed to apply to different worlds; how in earth or heaven, for instance, could the whole of the solid crust of the earth have crystallized from water when the vast majority of the rocks were almost insoluble? Nobody seemed to mind; it was a nice, neat, orderly hypothesis.

When the light at last dawned it came from the tiny lamp of a Scottish gentleman living in modest comfort in Edinburgh, whose academic studies had been restricted to medicine (owing to a liking for chemistry!). His geology was learnt from the best teacher, nature, partly in Berwickshire, but more particularly in East Anglia, whither he had gone to study farming. In 1785 he read a paper with the ill-chosen title of "Theory of the Earth"; it was published

in 1788; it attracted little attention until 1793, when by great good fortune it was attacked in abusive terms by Kirwan, the Irish mineralogist. The pride of the old Scotsman saved the science of geology, for with great determination in the face of ill health, James Hutton revised and augmented his work, and republished it in 1795. In 1797 he died without knowing that as a result of the literary and dialectical skill of John Playfair, and the experimental verifications of Sir James Hall, both his intimate friends, his views were to spread throughout Europe, to be combated by the leading geologists of the day, and to prevail; thus earning for their founder the proud title of founder of physical and dynamical geology. Of such is the Kingdom of Science.

A full view of Hutton's theory would be out of place; it cannot be better summarized than in the following words of Karl von Zittel: "When we compare Hutton's theory of the earth's structure with that of Werner or other contemporary or older writers, the great feature which distinguishes it and marks its superiority is the strict inductive method applied throughout. Every conclusion is based upon observed data that are carefully enumerated, no supernatural or unknown forces are resorted to, and the events and changes of past epochs are explained from analogy with the phenomena of the present age. . . . Hutton's genius first gave to geology the conception of calm, inexorable nature working little by little—by the raindrop, by the stream, by insidious decay, by slow waste, by the life and death of all organized creatures—and eventually accomplishing surface transformations on a scale more gigantic than was ever imagined in the philosophy of the ancients or the learning of the

schools. And it is not too much to say that the Huttonian principle of the value of small increments of change has had a beneficial, suggestive, and far-reaching influence not only on geology but on all the natural sciences. The generation after Hutton applied it to palaeontology, and thus paved the way for Darwin's still broader, biological conceptions upon the same basis" (*History of Geology and Palaeontology*, English trans., 1901, pp. 71, 72. To this mine of information I owe most of the facts in this chapter, except where otherwise stated).

Hutton's work was, of course, not without error; in particular he was unaware of the powerful aid of fossils in solving the problem of the succession of the rocks. By a fortunate coincidence another amateur, William Smith, ignorant of academic geology, had become enthusiastic over the collection of fossils, and, as a regional surveyor, soon became struck by the appearance of similar fossils in similar rocks in different parts of the country. Soon he was able to name the district from which a particular fossil had been brought. Disinclined to write, he dictated the sequence of the main divisions of English rocks, and later superintended the preparation of outcrop and sectional maps. As soon as the corresponding strata were sought for and discovered on the continent of Europe, it was recognized that in his principles of conformability, superposition, and fossil development the modest civil engineer had founded stratigraphical geology.

The genius peculiar to Hutton and that to Smith were combined in Lyell, who in his classical work, *The Principles of Geology*, published in 1830, laid the foundations upon

which all subsequent study has been based. Lyell's observation, learning, and influence were all the more necessary at this time, since Hutton's principle of the gradual changes, which alone are responsible for the carving out of the mountains, rivers, and valleys of our earth, was in danger of being once more rejected by the doctrine of catastrophism preached with eloquence and thoroughness by Cuvier. These early years of the nineteenth century were the most critical for the survival of the monistic view of the "solid ground of nature," for though the shaping of the earth's surface by a succession of gigantic earth ruptures and deluges is not irreconcilable with the monistic view—indeed, a certain degree of catastrophism has to be invoked to account for the upraising of the continental mountain chains—yet in the form of more or less universal catastrophism preached by Cuvier, in which whole races of animals and plants were supposed to have perished, it was necessary to repopulate the earth with new species created there and then—a view which strikes at the root of any monistic system. We shall have to refer to the biological aspect of this classical dispute later, but it is important to note that though at first Lyell strongly opposed Darwin's views, it is questionable whether the latter would have received anything like a general acceptance if Lyell had not paved the way for them by showing that the dominant type of change of the earth's surface is gradual and orderly, no forces having to be called into play to account for the change from, say, carboniferous times till to-day other than those which will have changed the face of the earth irretrievably by to-morrow.

By the end of the nineteenth century, then, the science of

geology had done its part in showing the unity of nature; and in addition the cosmogony of Kant and Laplace, through their popularization by Helmholtz, held almost undisputed sway. To these we must now turn.

Kant based his argument on the following facts: That the commonly recognized celestial bodies are of only two kinds, those luminous by their own nature, that is to say, by virtue of their very high temperature, and those whose luminosity depends on their power of reflecting the light of the former. The first group are called suns or stars, the second planets, or, if they revolve round a planet, satellites. The terms "sun" and "star" are assumed to be synonymous, since it is inconceivable that bodies as distant as the stars are known to be (by the absence of parallactic effect) could be visible to us unless self-luminous; further, if they shone by reflected light, the source of their luminosity would necessarily be far brighter than they. The stellar universe consists, therefore, of countless suns, each presumably surrounded by planets, though actually there is no evidence for this assumption except the analogy of the solar system.

Next, when we look up into the heavens on a clear night, we observe that the stars are by no means uniformly distributed, but tend to become more closely packed the nearer they are to the cloud-like band known as the Milky Way. The telescope, however, even so crude a one as Galileo's, reveals the fact that the Milky Way is no cloud, but a collection of individual stars, the density of whose distribution also varied roughly as their nearness to the plane of the band.

Again, the Milky Way is a regular circular band drawn

across the sky, and its centre seems to be approximately the position of the observer.

It is therefore difficult to resist the conclusion that the stellar universe consists of a huge plate (tilted with respect to our line of sight), in which the stars are congregated, being most densely packed in regions approximating to the plane of the plate.

To account for this Kant supposes a primordial chaos of tenuous matter; as it gravitates on itself its particles increase the number of their mutual impacts in a given time, thereby heating the mass. The more frequent impacts of the particles also generated rotation of the whole mass, until, owing to the centrifugal force becoming greater than the gravitation, rings of matter were shot off and in turn condensed to spheres, when the process repeated itself. In this way a vast system of central bodies would be ultimately formed, each surrounded by smaller ones, and they in turn by smaller ones still. And the whole system would approximate to one plane; and every member thereof would continue to spin in the same direction.

The hypothesis was borne out in fact to the extent that the solar system was known to consist of a central body surrounded by several small bodies approximately coplanar with it (recent work has shown that the actual deviation is sufficient to discountenance the theory), and all spinning in the same direction as itself.[1] But what struck Kant most forcibly was the fact that through the observations

[1] The satellites of Uranus, since discovered, unfortunately spin in the opposite direction. Kant recognized that his hypothesis involved a rotation of the galaxy, but rightly surmised that it would be too slow to be detected by any means then available.

of the Herschels he was able to point to the nebulae as external universes in the making; his grounds for this view being their approximately circular shape (actually they appear as ellipses of varying eccentricities owing to their planes not being perpendicular to the line of sight), their stupendous distance (shown by the weakness of their light as compared with their size), and the fact that no telescope, however powerful, had succeeded in resolving them. Thus, he believes, the principles of Newtonian physics must extend not only throughout our galactic system, but into universes isolated from ours by almost immeasurable vaults of space (*Theorie des Himmels*, in Ostwald's "Klassiker der exakten Wissenschaften," No. 12, p. 12).

This, the first cosmogony based on Newtonian physics, was a bold speculative feat, and came surprisingly near to what is believed at the present day. It had but one radical error, which is the assumption that rotation can be generated by impact. This, of course, can only occur if there exists rotation previously, the total *angular* momentum of a closed system remaining as constant as its mass. This defect was rectified by Laplace, who in ignorance of Kant's work put forward a nebular hypothesis otherwise almost identical with the latter's but based on precise mathematical demonstration. He maintained constant the angular momentum by starting with a hot rotating nebula which began to contract as a result of cooling. He proved that in such circumstances the nebula would spin faster and faster until the centrifugal force at the equator became equal to the gravitation, when an equatorial belt would be left behind as the main body continued to contract.

If this hypothesis of the birth of worlds had been correct, the dream of Descartes would have come true, for it assumes nothing but mass and motion and the laws connecting them. But though it has by no means been proved inapplicable to the explanation of the formation of *any* celestial bodies, it has been generally rejected as a theory of planetary origin; and for this reason, that the total angular momentum of the solar system is quite insufficient to account for an original disruption of the sun; and even if this be explained away on the assumption that some visiting star had "walked off with it," the more deadly criticism can be urged that, as Sir James Jeans has recently said, "Both theory and observation indicate quite clearly the fate in store for a star which rotates too fast for safety; it does not found a family, but merely bursts, like an over-driven flywheel, into parts of nearly equal size" (*The Universe Around Us*, 2nd edn., 1930, p. 231).

At the end of the nineteenth century, then, observation and analysis had not been sufficiently thorough to justify the assumption that the universe has grown according to the laws of matter and motion as they are known on earth.

CHAPTER XIII

THE UNITY OF LIFE

§ I. The Rise of Biological Science

At our present level of knowledge and of the means of observation we can sharply distinguish all things visible into living and non-living. Until the famous dictum of Descartes to the effect that animals are purely machines, and the bodies of men machines in the service of souls, it was generally supposed that the living world was different *toto coelo* from the inorganic, and that the behaviour of the former was to be interpreted in terms of "animal spirits" inexplicable in terms of the physical forces which by the more enlightened minds were regarded as measurable and predictable. But with the violent bringing to an end of the long reign of the Galenic "humours," by the action of which purely hypothetical entities all bodily events had been interpreted, a new era was opened, during which in increasing numbers the leading minds of the day turned towards the study of living creatures, not merely for the sake of curing human ills, but as to a field of enquiry to be interpreted by means of the hard-won principles of matter and motion gained in other spheres of investigation. The broad-minded, intemperate-bodied, and foul-mouthed hero of this change, Philip Bombast, better known as Paracelsus, approached the subject from the standpoint of chemistry; hence he expressed the phenomena of life as a balance of the interactions of chemical substances. The business of chemistry

became the making of medicines to restore the balance between the mercury, salt, and sulphur. The reform was a laudable one except that the three substances mentioned were not clearly defined, but regarded as prototypes to which the actual substances present in the body approximated. The difficulty of shaking off the universal miasma of Neo-Platonism is here made manifest; nor was this the limit of his partial return to alchemy, for in his oft-quoted term "Archeus" he undoubtedly personified the digestive process (von Meyer, *History of Chemistry*, p. 70). We must not, however, judge him too harshly for introducing this superfluous *deus ex machina*, for no one before him had the originality to see in the processes of the living organism any semblance of mechanism. Upwards of fifty years later Van Helmont, while failing to rid physiological chemistry of the gratuitous hypothesis of a benevolent genius directing the course of chemical events, nevertheless clarified the theory of digestion to a marked degree by replacing the vague *tria prima* by acids and alkalis upon whose relative concentrations in the stomach depended the normal digestion of the food; hence the welfare of the individual. To him those moderns, who in flatulence and colic are wont to resort to the handy "soda-mint" for relief, owe the first suggestion which has made possible this simple remedy. His late contemporary, Sylvius, purged of mysticism the theory of digestion with such completeness that he went to the opposite extreme, virtually denying to the organism any part in the proceedings, other than the elaboration of the gastric juice; with the result that in the then undeveloped state of chemical knowledge he must have caused

considerable discomfiture among his patients by the boldness of the chemical actions he sought to initiate in their stomachs with a view to improving on nature.

Meanwhile there had arisen in Italy schools of medicine which had developed physiology on its structural side. The stimulus to this had been given by Vesalius when in 1543, in his famous work *De Fabrica Humani Corporis*, he exposed the anatomical errors that rested on the authority of Galen with more acuteness and less redundant verbosity than that which had characterized the earlier attack on the latter's physiology by Paracelsus. With great thoroughness Vesalius demonstrated the mode of action of those "engines of the human body," as Sir Arthur Keith has called them, the bones and muscles. The Italian schools which became famous under his leadership—particularly at Padua—carried out accurate researches on the vascular tissue, sense organs, embryology, and other topics.

We have yet to record the most brilliant triumph of this period—the discovery of the circulation of the blood by Harvey. Descartes did well to seize upon this in support of his mechanistic theory of life (*Discourse on Method*, Scott Library edn., p. 59), for here we have a most wonderful mechanical pump, forcing the blood from one chamber to another, any return being rendered impossible by the admirable adaptation of the various systems of valves; driving it onwards by the elastic pulse in the muscular walls of the arteries whereby the pressure is more uniformly distributed; bringing it within smaller and smaller ramifying tubules to every organ and tissue in the body, collecting nutrient matter from some, delivering "spirits" to others, keeping

every part supplied with the necessities for growth, repair, and outwardly directed activities; starting before birth, expanding and contracting at a rate varied according to the body's needs from moment to moment, working smoothly, steadfastly, without conscious guidance, until that moment when life has ceased and the worn out or damaged body needs it no more.

What distinguishes Harvey's work as the outstanding physiological research of the age is that having given his "mind to vivisections, as a means of discovering the motions and uses of the heart, and [having] sought to discover these from actual inspection and not from the writings of others" (William Harvey, *An Anatomical Disquisition on the Motion of the Heart and Blood in Animals*, Everyman edn., p. 22) he developed his view according to the then but newly established principles of induction, each hypothesis arising out of direct observation of a large number of instances, and being subsequently verified by further search for the deduced consequences. Above all, in the last resort, the truth of the view depends on the fact that direct measurement of the quantity of blood (*op. cit.*, p. 84) passing through a given vessel in a short time shows it to be far greater than the total quantity in the body. Nor does he use any but clearly defined physical concepts, such as were in common use in reference to elastic membranes and columns of fluid in motion. Perhaps never in the history of science has so complete and faultless a demonstration been set out in so small a compass. It is not too much to say that the development of every branch of biological study was rendered possible by the success of this great doctrine. Moreover, in

regard to the nature of the "spirits" carried by the blood, his caution was that of a "prince of experimenters." Although he knew of the difference between venous and arterial blood, in the absence of any knowledge of oxygen or even of the true nature of gases at all, it was impossible for him to give a complete explanation.

In two directions, however, this discovery could give no fundamental guidance, namely, the origin and development of the organism, and the co-ordination of its activities by "nervous" action. Harvey himself was largely responsible for the solution of the first problem, when in his work *De Generatione Animalium* he everywhere illustrates, but contrary to common opinion nowhere explicitly states, the apophthegm "*Omne vivum ex ovo.*" He left no doubt that so far as the larger animals are concerned the mature organism comes into being by the development and growth of a very small mass of living matter. Malpighi, with the aid of the microscope, to which Harvey in his most active years had no access, described in detail the early differentiation of the embryonic organs, but unfortunately gave rise to the belief that a certain visible organization of parts is present from the beginning. To this we shall have to return later.

The second problem—that of nervous action—had always adapted itself to the mind given over to supernaturalism. Herophilos, indeed, had clearly pointed to the white threads present in the higher animals as "organs of the will," but when Vesalius centuries later verified this by experimental ligatures, he nevertheless explained their action as due to their power of conveying the animal spirit, "which is by far the brightest and most delicate, and indeed is a *quality*

rather than an actual thing" (italics mine; quoted by W. C. D. Dampier-Whetham, *op. cit.*, p. 133). Glisson in the seventeenth century showed that an essential factor in nervous action was the almost universal characteristic of living matter, irritability; but having made this discovery he proceeded to distinguish it as either "natural," "vital," or "animal" (Whewell, *History of the Inductive Sciences*, Vol. III, p. 428), which only served to cloud the fundamental significance of the discovery. The discovery by Willis of the ganglia, and the preparation by him of remarkably accurate "nerve maps" shed no light on the main problem; in fact, the complete elucidation of a simple reflex arc was arrived at only in the early nineteenth century by Johannes Müller. Of the essential causation of nerve impulses we know practically nothing even at the present day.

We have seen, then, that in the second half of the seventeenth century sufficient was known about the structure and behaviour of animals for them to be studied as, and by some investigators actually to be regarded as, machines subject to the same laws as inorganic matter. This attitude was productive of excellent results in the elucidation of the mechanism of muscular organs, of circulation, and of digestion; it had but a limited application to reproduction; and was completely departed from in the attempts to explain nervous action. This last was successively explained as "air" (Galen), a "mild sweet fluid" (Glisson), "nitrous" or "sulphureous acid" (late seventeenth century), "ether" (Newton in *Opticks*, Queries 23 and 24), a "fluid more gross than fire" (Haller), "imponderable fluid" (Cuvier) (Whewell, *op. cit.*, Vol. III, p. 428 *et seq.*)—a series which illustrates as well

as possible that when men of science are ignorant of the true nature of things they wrap up their ignorance in the folds of those concepts most in fashion at the time.

It may have been this failure to account for the most characteristic property of the higher organisms that induced Stahl to unite with phlogistonism a belief that although certain activities in organisms can be described in terms of chemistry and physics, yet these are all controlled by a "sensitive soul." This affords, of course, no more of an "explanation" than the wild speculations of the mechanists; but by setting a limit to the possibility of natural knowledge it saves the necessity for the invention of recondite concepts to clothe and dignify ignorance. This marks the birth of vitalism and biological dualism, between which and mechanism war has constantly been waged and will probably continue to be waged into the distant future. The problem itself is not for science, but for philosophy; we therefore defer a full consideration of it till later. But whatever may be the final decision as to this question, our knowledge of living organisms to-day is not only far more extensive than it was at the end of the seventeenth century, but nearly every step has brought greater unification within the sphere of the living world, thereby reducing to a minimum its fundamental differences (if any) from the inorganic. In this connection we are faced with the following problems, which it will be convenient to deal with separately: (*i*) the unity of living substance; (*ii*) the unity of growth and activity; (*iii*) the unity of origin; (*iv*) the unity of the living and the non-living.

§ 2. The Unity of Living Substance

The positing of this problem became possible only after the foundation of the relatively young science of organic chemistry. As we have already seen, it was the custom to postulate a different "fluid" or "spirit" to account for each activity. Although after the Renaissance this habit was largely curtailed, no very clear notions concerning the materials of life were substituted. The first triumph came with the discovery of oxygen and the elucidation of the composite nature of air. Both Priestley and Lavoisier carried out extensive experiments on the nature of respiration, and the earlier observations of Stahl and others were quickly interpreted in terms of the newly demonstrated theory of combustion. All living creatures that had been examined (including plants) required oxygen to enable them to carry on the activities of life.

With the work of Chevreuil on fats it became evident that the chemist in his laboratory could imitate closely the changes which proceed in the organism; but until Wöhler's synthesis of urea a kind of superstitious awe surrounded the belief in the "vital forces" of plant or animal which alone could produce these "organic" bodies upon which the chemist might thereafter exercise his ingenuity. With the researches of Liebig and Wöhler, however, began the great era of synthetic chemistry culminating in the artificial production from their elements of such complex products of plants and animals as fructose (1887, Fischer), uric acid (1897, Fischer), camphor (1906, Perkin and Thorpe), tropine (1900, Willstätter). With the exception of the proteins no class of substances existed, but had its representative

among the synthetic compounds; though it must be added that in no class has an optically active compound been produced except with the assistance, directly or indirectly, of the peculiar power of the living organism.

Years before the main classes of compounds existing in organisms had been artificially produced, biologists were being driven to the conclusion that there exists a prototype "living substance" to which the essential material of living creatures closely approximates within very narrow limits of variation. The approximate chemical and physical properties of the contents of cells obtained from various representatives of the lower animals were determined by Dujardin, but it was some time, and mainly owing to the labours of Schultze, before biologists began to recognize that the cell contents of animals and plants have very striking resemblances. It is only from this moment that the modern science of biology —that which studies the mechanism and reaction of living things *per se*—really dates. Schultze's arguments were based mainly on the irritability and response to chemicals which Mohl's "protoplasm" displayed, but more recent work (*e.g.* Haeckel's on the micro-organisms he called "protista") has shown that at the lowest levels of life no hard and fast line can be drawn between animals and plants; this is, of course, no evidence, unless it can be truly assumed that the more highly differentiated organisms have been developed in the course of ages from lower and simpler ones.

When the resources of modern organic and physical chemistry were brought to bear on the problem of the composition of protoplasm, it was found to be an emulsion

of proteins dispersed in a dilute saline solution. Though the proteins are not identical in plant and animal protoplasm, they both give the general reactions of proteins as a class. Since the behaviour of protoplasm is largely independent of its origin, it must therefore be rather to the physical than to the precise chemical constitution that this behaviour is due. But however that may be, we seem to be justified in supposing that there exists some constellation of chemical substances in complex equilibrium which can bear the characters of what we term "life." That this substance "breeds true" in the simplest organisms we know seems to indicate that there *is* a difference in different kinds of protoplasm, more so in that this is true also of those organisms in which no nucleus has ever been detected; hence we must regard "protoplasm" rather as a convenient abstraction than an actual "substance."

§ 3. The Unity of Growth and Activity

The study of this aspect of biology actually preceded that of living substance; but the two support one another, and what the one lacks in the power of conviction the other supplies.

To understand this problem clearly it is necessary to return to the years immediately following Harvey's implication of *Omne vivum ex ovo* and Malpighi's literal acceptance of the dictum in the sense that he taught that the embryo is already present in the egg before fertilization; the latter process merely consisting in the activation of the embryo into growth by the contact of the seminal contagion—a precise reversal of the Aristotelian view that the male

element alone bears the power of reproduction, the female being a source of nutriment. The Malpighian view, taken up by Leibniz, led to the "encasement" hypothesis, which naïvely stated that in the womb of every female was a completely formed embryo, in which, if it were female, there existed another, and so *ad infinitum.* This preposterous theory was opposed by another almost equally so, namely, that the moving bodies seen by Leeuwenhoek in the seminal fluid were animalcules, needing only the nutriment of the female element to enable them to grow into the mature organism.

After nearly a century of fruitless wrangling between the "ovists" and "spermists" Caspar Wolff drew attention to the fact that the "germinal spot" in a fertile hen's egg is at first quite structureless, even under the microscope, and that it is only after incubation that definite organs begin to appear, even these being at first quite unrecognizable. His work was neglected except by Haller and Bonnet, who rejected it on account of their belief that the immaculate conceptions of aphids were inconsistent with it. Pander, however, by his discovery of the three germinal layers of the higher animals, supported Wolff's views. But general acceptance was not forthcoming until Schleiden and Schwann had shown, the former for plants, the latter for animals, that there exists in every organism a unit of development, the cell, as a result of whose divisions the organism takes shape. Contemporaneously with the promulgation of this light-giving doctrine, von Baer published the results of an extensive series of observations, in which he showed that the ovum, the human no less than any other, was a single cell;

that it divided immediately on fertilization, ultimately giving rise to three distinct layers of cells, from each of which a specific group of organs subsequently developed. In 1880 F. M. Balfour published the first two volumes on *Comparative Embryology*, in which the whole animal kingdom was passed in review, every case investigated conforming in the main to von Baer's conclusions for certain types. Two groups only of the metazoa had failed to conform precisely as regards the germinal layers, but this difficulty had been cleared up by Huxley, who showed that the two layers of the Coelenterate embryos correspond to the hypo- and epi-blasts of higher animals.

The embryology of plants does not follow the same lines as that of animals, but in them also the mature organism is developed by the division of a single egg cell induced into activity by a "male" cell. The details of the process are usually exceedingly complex, owing to the fact that "alternation of generations" has become in the plant kingdom rather the rule than the exception.

The more extensively we compare the two kingdoms the more we are driven to recognize, not only the widespread and intimate co-operation between them, but also the close parallels between their several activities. All organisms, whether plant or animal, develop, or can develop, from the union of two cell nuclei, with subsequent division and differentiation of the resulting cells into tissues; moreover, the division of these cells follows the same lines approximately in both. Both need to absorb food from their environment, and, whereas plants in the main synthesize it from simple salts and gases, while animals break down and

rearrange the products of other living organisms, yet plants are known (*e.g.* Drosera) which can and do catch and digest animals; others which, like the moulds, grow on dead plants or animals; and there are "animals" (though these are rare), like Euglena, which possess the means of synthesizing food. Both have conducting vessels, both need oxygen as an essential condition of life, both display movement, sensitiveness to stimuli whether physical or chemical, and both can, and usually do, reproduce by the union of sexually differentiated cells. Therefore life is one, as we know it to-day, in its nature and activity; but is it one in origin? To answer that question, so far as the evolutionists at the close of the nineteenth century thought that they had answered it, is our next task.

§ 4. The Unity of Origin

To the biologists of the eighteenth century nothing appeared more certain than that God had created each creature after its own kind, and had endowed it with the best possible equipment for the conquest of its environment. Linnaeus, indeed, had revolutionized taxonomy by placing man in the same natural order as the apes, and Buffon had tentatively suggested that the relationships brought into greater prominence by the remainder of Linnaeus's system pointed to a common origin of the various animals; yet he afterwards withdrew this incautious remark. But, as has been hinted already, so confirmed was the mind of the eighteenth century in the doctrine of fixity of species that he who did more than any other to provide the evidence which compelled men to reconsider the question, Cuvier,

used the whole weight of his learning and eloquence to crush the opinion which to him appeared as unscientific as it was infamous.

The history of the doctrine of evolution, had we space to outline it, would go far to illustrate the monistic tendency in science, which recurs from time to time in all its branches, often in conflict with the best intellects of the day. In the crisis which came at the turn of the century we can account for Cuvier's determined resistance in no other fashion than to suppose a religious prejudice; for his studies in comparative anatomy almost at once placed this subject in the forefront of the departments of biology. And, which was more, he filled to some extent the gaps between the living representatives by accurate interpretation and reconstruction of the fossil remains. This latter contribution was the more important since the principle of unity of type which he implicitly set up as the guide to classification was not in itself a convincing piece of evidence for a belief in common origin; in fact the existence of clearly defined types whose representatives varied little among themselves but were fairly sharply demarcated from those belonging to other types might be construed as evidence for the separate creation of those types; since, it might be argued, given a primordial simple type capable of variation, there should be found in existence at a later date all manner of gradations of change and development from it. But among living organisms this is not so. When, however, we cleave the sedimentary rocks, the order of chronology of which may be roughly determined by the principles of superposition and conformability, we have races of organisms bearing

certain resemblances to the living types, passing through a developmental phase as we pass upwards through the superimposed strata, and at length dying out. These supply some answer to our doubts in a variety of ways. Nevertheless the value of this evidence is largely nullified by Cuvier's quite gratuitous hypothesis of catastrophes occurring at more or less regular intervals and sweeping into destruction all the organisms populating large areas of land and sea.

Opposed to the belief of the influential Cuvier there were several naturalists imbued with an intuition of the truth of common origin, and determined to find a mechanism to account for the facts as they are. Chief of these were Goethe, De Candolle, Lamarck, and Erasmus Darwin.

Goethe and De Candolle independently put forward the principle of metamorphosed symmetry to account for the great variety of forms having a common structural basis. Goethe paid most attention to the production of flowers by means of variously metamorphosed leaf elements: stamens, carpels, petals, and sepals alike being leaf-life organs pigmented, fused, and arranged in whorls of approximately constant number. De Candolle extended the principle to account for such apparently anomalous forms as the Euphorbiaceae. This was an important contribution to the problem of unity of type in plants to which little attention might otherwise have been paid, and it emphasized the need for looking for a mechanism of evolution; but it can hardly be said to have provided any. The principle found an able protagonist in Geoffroy St. Hilaire, who extended it into the animal kingdom.

Lamarck, on the other hand, recognized that the essence

of the problem was to account for the fact that some races survive while others perish. This was of cardinal importance, and stands eternally to the credit of the great naturalist whatever may ultimately be the fate of the mechanism he proposed. This was to the effect that organs may be capable of extended development if constantly called into use; of atrophy, if left in idleness, and that these "acquired characters" may be inherited. This being so, the multitude of species which now inhabit the earth have gradually come into existence owing to the differences in the extent to which different organs have in the past been used, such differences of use leading to differences of development, and ultimately, after generations of cumulative inheritance, to such striking differences as now distinguish species.

This hypothesis was criticized on two grounds. First, that it involves an element of teleology, in that an animal must persist in one activity to produce any change, and there is no reason why it should persist unless it "knows" that it *will* be to its advantage. Second, that although it is easy enough to show that an organism transferred to a new environment will make adaptive changes to fit itself to that environment, there is no evidence that such changes can be inherited.

It is Erasmus Darwin whom we must regard as the morning star of the modern evolutionary theory. He alone caught sight of the importance of the elimination of the unfit as a result of what he called the "law of battle." Nor did he overlook the converging lines of evidence from many other sources as the following quotation will show: "[from] the metamorphoses of animals, as from the tadpole to the

frog, . . . the changes produced by artificial cultivation, as in the breeds of horses, dogs, and sheep, . . . the changes produced by conditions of climate and season, . . . the essential unity of plan in all warm-blooded animals, . . . we are led to conclude that they have been alike produced from a similar living filament" (quoted by W. C. D. Dampier-Whetham, *op. cit.*, p. 294).

There are several seeds here which were cultivated by his more famous grandson, Charles Darwin; but what gave the latter (as also A. R. Wallace, who shares with Darwin the glory of the theory of natural selection) the indispensable clue to the problem was the reading, "for amusement," of Malthus's tract on population. Here he saw that in Nature's reckless prodigality, combined with her sublime indifference to the fate of the countless hordes of organisms she releases every minute, was to be found a key to the origin of species.

The famous work which, no less than the Bible, Euclid's *Elements*, and Newton's *Principia*, has had the profoundest influence on European civilization is well known in its broad outlines; but since it has been much distorted, not only by members of the general public, but also by many able and specially trained minds who should have known better, it will be necessary to restate at some length the case there given; it being understood that the following summary makes no pretence at being a complete abstract, but claims only to put us in a position, during our subsequent investigation, of basing our arguments only on what Darwin wrote, and not on what his detractors, and, worse still, his most enthusiastic disciples, have implied that he wrote.

The argument opens with the expressed belief that the formation of species is proceeding under our very eyes, for the fancier, by breeding from those birds selected for the desirability of their variations from the normal, has during the course of a large number of generations developed strains of pigeons which differ from each other not only in superficial characteristics, but in skeletal structure, more than do distinct species in the wild state; yet the evidence is almost perfectly conclusive that all these domestic breeds are descended from one wild species. Turning to the state of nature, Darwin points to the extreme difficulty of drawing a sharp line between true species and mere varieties, owing to the great range of variation, particularly in certain genera; and he points out that "to discuss whether they are rightly called species or varieties, before any definition of these terms has been generally accepted, is vainly to beat the air" (C. Darwin, *The Origin of Species*, reprint in the Unit Library, 1902, p. 47). Subsequently he concludes that he must "look at the term species, as one arbitrarily given for the sake of convenience to a set of individuals closely resembling each other, and that it does not essentially differ from the term variety, which is given to less distinct and more fluctuating forms. The term variety, again, in comparison with mere individual differences, is also applied arbitrarily, and for mere convenience' sake" (*op. cit.*, p. 50). What is it, then, that determines the ultimately fixed tendencies of certain variations to the detriment of others, whereby a number of clearly demarcated species is small compared with the almost limitless number of individual differences? Darwin states his hypothesis in the following

oft-quoted passage: "All these results, as we shall more fully see in the next chapter, follow inevitably from the struggle for existence. Owing to this struggle for life any variation, however slight and from whatever cause proceeding, if it be in any degree profitable to an individual of any species, in its infinitely complex relations to other organic beings and to external nature will tend to the preservation of that individual *and will generally be inherited by its offspring*. The offspring, also, will thus have a better chance of surviving, for of the many individuals of any species which are periodically born, but a small number can survive. I have called this principle, by which each slight variation, if useful, is preserved, by the term of Natural Selection, in order to mark its relation to man's power of selection" (*op. cit.*, p. 58; italics mine).

There is no ambiguity here; and every aspect of the problem—the colossal scale of infant mortality in nature, the complexity of an organism's relations with others, the importance of certain characters in the competition of males for the most favoured females, and the struggle between the males themselves—is developed by Darwin with the most marvellous wealth of observation and experiment. But there is one fundamental weakness in the argument which is bound up with the italicized passage above: variation is admittedly very slight, so that one generation could not have any appreciable effect on the character of the species; the influence to be effective must be cumulative, and it can be cumulative only if inherited; and that is just what cannot be proved. Indeed, the facts of reversion go to show that such variations are not inherited; they are

merely called out in each generation by the exigencies of the environment, only to disappear rapidly when those demands have no longer to be met. The analogy of domestic selection is not as cogent as Darwin believed, since there we are not dealing with the very gradual elimination[1] of the individuals lacking a *very slight* deviation in a particular character, but with the singling out by the breeder of the animals or plants which occasionally show abrupt and striking differences; such differences have more recently been proved to differ fundamentally from the general capacity to vary possessed by every individual, which Darwin himself clearly had in mind. Moreover, he seems to have fallen into definite error when he says, "I think there can be little doubt that use in our domestic animals strengthens and enlarges certain parts, and use diminishes them; and that such modifications are inherited." The first part of this statement is unquestionably true (*cf.* the diagrams given by Sir Arbuthnot Lane of skeletal and other changes in men following various callings—*The Prevention of the Diseases Peculiar to Civilization*, 1929); for the second there is no convincing evidence.

Apart from this criticism, which unfortunately nullifies the hypothesis of natural selection being the principal

[1] For that is what "natural selection" really amounts to, since an advantageous character can cause an *increase* in a variety possessing it only relatively, due to the *decrease* of those lacking it; the expression "favoured races" in the sub-title was unfortunate, since it implied some positive choice and endowment, a view which Darwin himself certainly did not hold. (I assume such passages as that in § 1, p. 179, *op. cit.*, were meant by Darwin to be taken in a figurative sense; but his mode of expression was certainly unfortunate.)

cause of the evolution of new species from common stocks, Darwin himself anticipated, and in my opinion adequately met, the objections which could be raised against it, the facts upon which it is based being assumed true. Thus he answers the very natural objection that there should be no species at all, but only dominant types with small numbers of intermediate varieties of all kinds, by showing that not only may geographical changes have led to the annihilation of the intermediate types, but also that adequate search of the fossiliferous rocks may ultimately reveal their sometime existence—a prophecy afterwards to be realized by Huxley (on the forbears of the horse) and others. Indeed, the very incompleteness of the geological record, with its abrupt changes in the character of the dominant fauna over areas of continental dimensions, is just what is to be expected as the inevitable result of the struggle for existence, since those organisms (*e.g.* trilobites) which have by a high degree of specialization become most adequately adapted to the existing conditions, would, on a change in those conditions, be the most rapidly and completely eliminated.

Again, if it is urged that the continental fauna and flora of the Western Hemisphere differ entirely from those of the Eastern, which could hardly be true if all were descended from a common ancestor, Darwin replies that the enormous time during which these continental masses have been separated would account for the present wide divergence of living types; moreover, once again, in his brilliant studies of the endemic types, present on isolated islands, and their relative degree of similarity to those of the nearest mainland in proportion to its nearness, he turns the argument in his favour.

Lastly he deals decisively with those views which would see in each organism the perfection of the adaptation of form to function; on the contrary, the greatest similarity in form is adapted quite needlessly, unless it be as a result of gradual modification of a prototype, to the most diverse functions. Of what conceivable use, for instance, to birds is the multiple plate structure of the skull which serves in mammals to facilitate parturition? What, again, is the use of the loop in the arteries in the branchial slits of mammal embryos; of what the value of stripes to a lion whelp, or the wings of certain insects which lie beneath wing cases firmly soldered together? On the hypothesis of natural selection, on the contrary, it is *disuse* which has led to the existence of rudimentary and atrophied organs. "At whatever period of life disuse or selection reduces an organ, and this will generally be when the being has come to maturity and to its full powers of action, the principle of inheritance at corresponding ages will reproduce the organ in its reduced state at the same age, and consequently will seldom affect or reduce it in the embryo. Thus we can understand the greater relative size of rudimentary organs in the embryo, and their lesser relative size in the adult. But if each step of the process of reduction were to be inherited, not at the corresponding age, but at an extremely early period of life (as we have good reason to believe to be possible), the rudimentary part would tend to be wholly lost, and we should have a case of complete abortion" (*op. cit.*, pp. 418–19). Here Darwin seems to imply that the organism inherits not only the *pattern* of its parents, but the temporal relations of the process by which that pattern is realized.

I have attempted to state the salient features of Darwin's hypothesis that natural selection is the mechanism whereby complete and endless biological evolution proceeds. The immense enthusiasm which it inspired in some quarters, no less than the bitter hostility which brought forth the obloquy of others, testifies to its outstanding importance to the development of the ancient theory of evolution—a theory at least as old as Anaximander, and one quite earnestly advocated by St. Augustine and St. Thomas Aquinas. I have expressed the view generally adopted, I think, by present-day biologists, that the hypothetical part of his restatement of the theory is incomplete, founded, indeed, on a misconception of the laws of inheritance, which, in fact, were in Darwin's day virtually non-existent. Darwin stands in relation to biological philosophy as Descartes does to cosmology; in that while the latter showed that a mechanical interpretation of the universe was no empty dream, Darwin did the same service for biological evolution. But whereas the system of Descartes, founded on definitely false premises, had to be rejected completely, that of Darwin, built up on the greatest assemblage of accurate facts correlated with the greatest mastery the science of biology has ever seen, will in the hands of the Einstein of biology be reshaped no more fundamentally than has been the cosmology of Newton. Our last words on this matter must be deferred; but since the monistic philosophy of Haeckel chose *Darwinismus* as one of its corner-stones, it will be necessary to close our account of the unity of descent by a brief reference to an application of Darwin's views, to which the great founder himself paid but passing attention, that is, man's place in nature.

Darwin's abstention from the expression of any clear-cut views on the origin of man was probably due to the recognition that any such statement must involve him in a publicity such as he shrank from. What the man of peace wished to avoid, however, his Pauline Apostle, T. H. Huxley, rushed into with the joy of conflict, caring nothing for the consequences. The gauntlet was thrown down in 1860 in his famous duel with Wilberforce; but the arguments for the inclusion of man in the evolutionary scheme were first set out in full array in the three lectures published under the title of *Evidence as to Man's Place in Nature.* In this volume, having reviewed the existing knowledge concerning the man-like apes, and having shown that just in those embryological phases in which man differs from the dog he resembles the ape, he proceeds to demonstrate that a detailed comparison of the skeleton and brain of the various apes and of man leaves no shadow of doubt but that the several species of the apes differ among themselves more than does man from the gorilla. There is no option, then, but to assume that man is genetically related to the apes; that he constitutes, indeed, but one family in the order of Primates. Huxley was careful to point out that this result constitutes no sort of proof that man is descended from the apes by natural selection; it merely shows that if the theory of natural selection is true, and he admitted that the evidence was very strongly in its favour, then there was no justification whatever in placing man outside the sphere of its applicability. In the third lecture—"On Some Fossil Remains of Man"—he set forth the characters of the Neanderthal skull, and concluded that although it pos-

sessed simian characters it nevertheless belonged to a man; so that neither this nor any other fossil existing in his day furnished anything like a link between man and ape.

The final problem which the new doctrine of evolution opened up was the question as to whether, granted that the bodies of men and apes differ by no unbridgeable gulf, there is, as the theologians determined there must be, some psychic endowment of man which is wholly absent from any ape. Huxley was of opinion that there was not, but the matter is one of such paramount importance, and one concerning which even to this day much dissension rages, that it is desirable to quote in full a passage which summarizes Huxley's view and his own qualification of what it involves. "I have endeavoured," he says, "to show that no absolute structural line of demarcation, wider than that between the animals which immediately succeed us in the scale, can be drawn between the animal world and ourselves; *and I may add the expression of my belief that the attempt to draw a psychical distinction is equally futile, and that even the highest faculties of feeling and of intellect begin to germinate in lower forms of life.* At the same time no one is more strongly convinced than I am of the vastness of the gulf between civilized man and the brutes; or is more certain that whether *from* them or not, he is assuredly not *of* them" (*Man's Place in Nature*, Everyman reprint, p. 102; italics my own).

It was perhaps rather unreasonable of Huxley and his fellow campaigners to expect humanity at large, brought up on more than a thousand years' acceptance of the God-like image of man, to swallow at one gulp this doctrine,

which not only makes of the Mosaic story of the creation a pure fairy-tale but casts grave doubts on the existence of man's immortal soul. True, Huxley was at all times earnest in his declaration that the truths of science are subjective truths, and on no account to be made the exclusive basis of any metaphysic. His British contemporaries, mainly, one suspects, because they were in any case insufficiently interested in philosophy, refrained from going the whole hog. In Germany, however, the very gifted biologist and scientific humanist, Ernst Haeckel, marshalled the scattered forces of nineteenth-century materialism under the banner of scientific monism. This all-embracing system, though it developed little if at all the idea of monism as a philosophical concept, is of paramount importance to us as showing what are the pitfalls of any *Weltanschauung*, monistic or otherwise, which openly ignores the labours of the great thinkers of the past, who have sought to cast light on the nature of reality and the limits to our knowledge of it.

We shall attempt, therefore, to give a succinct outline of Haeckel's monism, contenting ourselves at this stage with a criticism only of his facts and immediate inferences therefrom; the validity of the conceptual scheme will demand a much more thorough analysis in the Third Part of this work. But before we start on this task we have briefly to consider the problem which is probably even older than that of evolution, namely, the origin of life itself.

§ 5. The Unity of the Living and the Non-Living

It might at first be thought that the recognition of the mechanical nature of life-processes would have brought

about an equally strong belief in the spontaneous generation of living organisms, that is, the gradual emergence of living from non-living substance under the influence of none but physical forces; but such was not the case. On the contrary, it has all along been just those investigators who most rigidly adhered to the methods of enquiry elaborated for the mechanical sciences who have done most to demonstrate the falsity of every such reported generation. Nevertheless, the evidence is, of course, mainly negative; few biologists would be bold enough to deny its possibility, at any rate at the lowest level of organized being. But that just what constitutes this lowest level has been asked at different stages of the development of biological science, and has at each received a different answer, is what we shall endeavour to show by a brief review of the history of the subject.

The first systematic views on generation seem to have been advanced by Aristotle, who, while convinced of the orthogenetic succession in vertebrates, believed that in the case of the lower animals some "do not originate in animals of the same species, but their production is spontaneous, for some of them spring from the dew which falls from plants. . . . The gnats originate in ascarides and the ascarides originate in the mud of wells and running waters that flow over an earthy bottom" (quoted by L. T. Hogben, *Principles of Animal Biology*, p. 197). Views similar to these, and even grosser ones, persisted until after the Renaissance. The experiments of Redi on the maggots which are found in meat gave so convincing a demonstration of how the belief of their spontaneous generation therein had arisen

that none, save those rooted in the belief that the age of miracles had not passed, doubted that as far as the lowest known levels of organized beings were concerned orthogenesis alone held sway. But the invention of the microscope about this time revealed worlds of minute living creatures not hitherto suspected; and these apparently arose spontaneously from infusions of meat and vegetable matter; but not after they had been *boiled,* as Spallanzani clearly showed. Once again the ghost was laid. It arose again a century later, when Pouchet announced that germs were generated spontaneously from the air. In a masterly series of experiments conducted under extreme differences of conditions Pasteur cleared up the whole question, and incidentally launched himself on those researches which culminated in the foundation of the science of bacteriology (fully described by Vallery-Radot in *La Vie de Pasteur,* pp. 97–110). Nevertheless, one difficulty still remained, namely, that in certain cases infusions inoculated with dry, infective material still produced organisms even after prolonged boiling; this fact was used by Bastian in support of his prejudice in favour of spontaneous generation. Tyndall, however, working on the lines made famous by Pasteur, showed that in the case of *Bacillus subtilis,* obtained from desiccated hay, prolonged boiling alone will kill the organism and render the infusion permanently sterile. In his *Essays on the Floating Matter of the Air* he writes: "The argument that bacteria and their germs, being destroyed at 140°, must, if they appear after exposure to 112°, be spontaneously generated is, I trust, silenced for ever" (*op. cit.*, p. 318). And so it has been; for now we recognize that certain species of bacteria have the

power of developing highly resistant spores (the "germs of bacteria" mentioned by Tyndall) which, when conditions are once more favourable, may blossom forth again into active life. At the same time, one wonders whether this same property, which the simplest organisms have, of not only suspending the activities of life but of taking upon themselves some at least of the properties of lifelessness, may not some day supply the key to the problem of the relation between the living and the non-living.

All organisms whose existence was known or even suspected at the end of the nineteenth century, then, must in default of any positive evidence be assumed to be developed only from pre-existing organisms of the same kind.

To the deeper philosophical problem of the nature of life we shall return later. Meanwhile we may consider Haeckel's synthesis of the date of science such as we have shown them to be at the time he undertook this task.

CHAPTER XIV

THE NATURALISTIC MONISM OF ERNST HAECKEL

If we are to form a just appreciation of the message of Haeckel we must from the start divest ourselves of all those traditional habits of thought and speech in which we are wont to assess and expound the great aprioristic philosophies; it would be as futile to dismiss him for lack of rigid dialectical development of his thesis as to reject Spinoza because he but seldom brings experimental evidence to his aid. We must rather recognize in it a development of eighteenth-century materialism. Now materialism properly means that philosophy which accounts for reality wholly in terms of matter, *i.e.* substance possessing inertia. Since Haeckel categorically denies the priority of matter over energy and "psychom" (*infra*, p. 252), his "system," as he himself contended, is not in strictness materialism. It has been called the *Haeckelscher Monismus* in Germany, which is probably the only suitable description. The term "materialism" will, however, be used here.

There is, on the other hand, no question about the empiricism of his philosophy. Now, though we may not agree with it, we must allow to the empirical method a recognized place in the armoury of philosophy. Yet when we try to understand Haeckel, having due regard to this fundamental standpoint, we are met at the outset with a difficulty which no philosopher has any right to put in our way: I

mean the looseness of his terminology. On the third page of his book *Monism—The Confession of Faith of a Man of Science* he says, "We unambiguously express our conviction that there lives 'one spirit in all things'" (*op. cit.*, English trans. by J. Gilchrist, 1894), and on the next page he asserts that "we refuse to accept the distinction usually drawn between the natural and the spiritual."

Evidently the terms "spirit" and "spiritual" refer to two different notions. Now it may be argued that since on page 3 the term "spirit" occurs in a quoted phrase, it is not meant to be taken literally; to which we must reply that when a philosopher is laying down the central position of his system it ill behoves him to use any but "unambiguous" terms. We shall meet other and more serious examples of this in the course of our study. I mention it here to show the extreme difficulty of expounding Haeckel's views without apparent contradiction. That the contradiction is more apparent than real is urged by Dr. Heinrich Schmidt. Though this may often be the case I find myself in agreement with Professor Georg Adickes, who speaks of Haeckel's "*Orgie der Begriffsverwirrung*," which exempts his reader from the necessity of striving to form any clear idea of what Haeckel's system really is (*vide* W. von Schnehen's article in *Der Monismus*, edited by Arthur Drews, Bd. 2, p. 104, note). Often, too, the pure truth in his writings lies hidden under a cloud of rhetoric, inspired, we may believe, by the desire to win the suffrages of all sorts and conditions of men, the love of whom warms every line he wrote.

The main positions of Haeckel's monism may be stated, as he himself has done, in a few sentences: The universe

is bounded neither in space nor time; its substance (with its two attributes matter and energy) fills the whole of space, and is in constant motion, resulting in periodic development and decay; countless worlds move through the all-pervading ether; of these, one is our sun, and of its planets, one is our earth; on the earth during the course of ages have arisen successively simple organisms, vertebrates, mammals, primates, and man.

Before attempting any criticism of the above it will be well to see how each section is developed in detail.

With a wealth of illustration he proves that man is a product of nature genetically related to the apes, and through them to the rest of the world of animals; and this is true, whether we argue from the results of comparative anatomy, physiology, or embryology. No special "life force" distinguishes our activities from those of other animals, and they in their turn can be reduced to the interplay of physico-chemical processes between complex carbon compounds. We, in common with nearly all living creatures, come into existence at the instant when a sperm nucleus fuses with an egg nucleus; how, then, can there be question of our immortality? In no way is our indissoluble relationship with the lower members of creation more clearly established than by the unquestionable "fish phase" through which we pass in embryonic life: for the evanescent development of gill clefts can be in no way explained save as a vestige from a far-distant ancestor leading an aquatic life.

The unity of man and animals is thus established, if we agree to ignore the existence of his soul; for what has been written above will be generally acceptable now to all think-

ing people. But when we come to the question of man's mental endowment we are at once engaged on thorny problems—problems which strike at the root of the whole question of monism.

Haeckel approaches the agelong problem of body and soul from three points of view: experimental psychology (which in his opinion is a branch of physiology), evolutionary theory, and speculation. These three, he believes, constitute the method of science. Now experiment and observation give no evidence in support of the traditional view of the essential distinction between body and soul; on the contrary, this assumption is founded on the myths of a prescientific age, and is unintelligible to one who accepts the doctrine of conservation of substance. But if what has been called the soul has no existence apart from the body, then animals, whose bodies differ from ours only in respect of a gradually diminishing complexity and adaptation, should have souls differing from ours analogously; and this, as the work of Romanes in development of Darwin's study of instinct has shown, is just what we do find. Haeckel and others extended this study into the realm of the protista or acellular organisms, and his conclusions are among the most interesting of all his views. We shall therefore describe them in some detail.

Lengthy observations and study of various protista, he writes, have convinced him that every living cell has psychic characteristics. In the simplest protista the whole body is psychically endowed for both sensory and motor discharges, but already in the infusoria the rudiments of special organs become manifest. At the level of the more complex types

of colonies we see the specialization of certain cells to particular functions; and in the simplest coelenterata, although there are no nerve *cells*, there is a sharp line of demarcation between sensori-motor ectoderm and assimilatory endoderm. When we come to the triploblastic groups we find special nerve cells developed, and, what is most important, these cells not only ramify throughout the whole body, but meet each other in common centres, or ganglia, so that a sensation received from one part of the body may call forth responses from a totally different part or parts. In the lower phyla, such as the annelida, the whole surface of the body appears to receive stimuli of all kinds, but the higher we go up the scale the more do we find certain organs developed to localize and distinguish particular stimuli.

Nowhere is there a break in the sequence. Just as in the simplest protista the whole animal takes part in every activity, while in the higher organisms first cells, then tissues, organs, and systems, are specialized to the task of nutrition, reproduction, etc., so we find with increasing development of the characteristically formed nerve cells, and with further complication of the ganglionic system, greater powers of response to the altering conditions of environment. Can we, then, escape the conclusion that the noble intellect of man, the soul itself, is nothing but the functioning of his unthinkably complex central nervous system with its associated sympathetic chains? To drag in any other substance or mechanism is merely to multiply hypotheses where none is needed.

But what of consciousness? Here experiment points clearly to the view that consciousness is the functioning of

the brain, or more exactly of the cerebral cortex; for not only after the destruction of the brain does an animal, though in a sense living, fail to give any of the indications usually associated with the conscious state, but by correlation of failures in the normal functioning of consciousness with lesions of the brain revealed by autopsy it has been possible to assign to fairly definite regions of the brain specific functions. Individual nerve fibres have also been traced to their sources, principally by the ingenious method of "degenerative section." Again, from the point of view of evolutionary theory we may trace an unbroken sequence in the elaboration of conscious states from the dim almost wholly "unconscious consciousness" of the amoeba up to the highly sensitive and marvellously varied mental endowment of cats, dogs, elephants, and apes, which, in its creative fancy and capacity for education, particularly in the realms of play, courtship, and parental care, differs less from that of savages than theirs does from the surpassing wonder of a Goethe or a Shakespeare.

Haeckel, of course, qualifies the above views by admitting that all knowledge of consciousness of organisms other than the observer himself is conditioned by the validity of the analogy between consciousness and its expression in behaviour (*Die Welträtsel*, p. 103). But if this analogy holds, then, as for psychic activity in general, so for consciousness there is no warrant for calling an arbitrary halt anywhere —at any rate between the higher mammals and man; and this conclusion is supported by the parallel development of the organ of consciousness.

Nowhere in his writings is Haeckel's sagacity more ap-

parent than when he calls attention (*op. cit.*, p. 103) to the striking resemblance between the unconscious psychic activity of the simplest organisms and those sudden impulses of our own, which must spring from some unconscious level. For here, if anywhere, is to be sought the connecting-link in the chain of increasing complexity of psychic life running parallel with that of the central nervous system.

The conclusions for Haeckel are these: That the human "soul," as self-abiding substance, is a myth; and that the problem of consciousness is the business of physiology (*op. cit.*, p. 109). With the first of these we may at once agree. But the second is a rock upon which all materialistic monisms must break. I shall not enlarge on this subject here, as it is one of fundamental importance, and as such will be most suitably dealt with towards the end of our study.

We have said enough to show how Haeckel demonstrated the fundamental falsity of the view which makes of man a special creation, endowed with a unique phenomenon called the soul, which "rules" the body as a driver whips and guides a horse. Whatever may be our ultimate estimate of his philosophical system, we may pause a moment in gratitude to this patient man of science, whose synoptic view of organic nature has done so much to rid the modern world of ghosts and demons; who has taught us that to starve and warp the body is to impoverish the soul; whose influence will be felt for years to come in the gradual awakening to the fact that we are one with nature, which we can in no wise rule without obeying.

We pass on now to the consideration of the fundamental basis of Haeckel's world-view as philosophical system,

namely, what he calls *Substanzgesetz*. As experimental facts Haeckel accepted the conservation of mass and conservation of energy, with the qualification that these two principles are in fact inseparable (*op. cit.*, pp. 128–9). He further states that this qualification was recognized by the majority of men of science at that time (1908); but he gives no evidence either of this "recognition," or of what was meant by it; indeed, in another place he alludes to the transformation of radium into helium (*op. cit.*, p. 134), without stating whether any mass disappears or not, while in a third he states that every investigator is so convinced of the conservation of mass that the denial of it would be inconceivable (*op. cit.*, § 2, p. 128, last four lines). What we are to make of this I confess I do not know. Even if he was unaware that the conversion of one element into another may be accompanied by a detectable loss of mass, he should at any rate have hesitated before stating that the opposite was inconceivable. But if he *was* firmly convinced of the conservation of mass, and knew, as he must have done, that a radium salt is a continuous source of energy, what becomes of the conservation of energy, unless the energy merely escapes "through the cracks" in the atoms! Yet even if such a stretching of the concept of energy be allowed, why should "men of science" (*Naturforscher*) "recognize" (*anerkennen*) the inseparability of the two conservation dogmas, that is, if there is no evidence of interconversion? As a working postulate, yes; but if *science* is to "recognize" concepts and relationships merely because they fit into a dogmatic cosmology it becomes a far greater source of danger than the religion upon which Haeckel

poured such floods of somewhat abusive rhetoric; for this at least *admits* the part played by "revelation."

But far worse is to come. The fusion of the two experimental laws, to which Haeckel gives the name *Substanzbegriff*, is now given the authority of Spinoza, whose system is described as follows: "This universal substance or divine world-being displays to us two different aspects of its true essence, two fundamental attributes: matter [infinite extended material substance] and spirit [*Geist*] [the all-comprehending thinking energy-substance]" (*Die Welträtsel*, p. 130). We may wonder what exactly is meant by identifying Spinoza's attribute of thought with thinking *energy*; a later passage makes this only too clear: "These modes are corporeal things, material bodies, when we consider them under the attribute of extension ('space-filling'), on the other hand forces or ideas, when we consider them under the attribute of thought ('energy'). . . . For us also matter (space-filling stuff) and energy (movement-producing force) are only two inseparable attributes of the one undivided world-being, the one substance" (*op. cit.*, p. 130). Here thought (*Denken*) is identified with energy in what purports to be a statement of Spinoza's teaching, and energy with movement-producing force in Haeckel's system. Thought, presumably, is therefore a form of energy. Now when I look at a stationary pendulum I apprehend it under the attribute thought, but my knowledge of its inertia tells me that it exists also under the attribute extension; but what am I to understand by its apprehension under the attribute "energy"? And how is this apprehension to be distinguished from the apprehension of its *condition* when

set in motion whereby if it strike me on the head it shows itself to be possessed of very different properties from those when stationary? If Spinoza really meant by the attribute thought that which his learned contemporary was measuring in terms of half the product of a mass and its velocity squared, I will confess myself more of a Dutchman than ever Spinoza was. On the contrary, we have seen reason to believe that Spinoza's interpretation of the attribute *extension* at least approximated to the modern concept of energy (*vide* p. 118 *supra*).

Not content with having compelled one attribute to serve for two different kinds of experience Haeckel next calls in a third attribute, summarizing his *Substanzbegriff*, as follows: "The three fundamental attributes of substance: (*a*) Space-filling, or 'extension,' stuff [= matter]; (*b*) Movement, or 'mechanism,' force [= energy], and (*c*) Unconscious perception [*Empfindung*], or 'world-soul,' spirit [= *psychom*] are consequently common fundamental properties of all bodies" (*Die Welträtsel*, p. 132). How this is to be harmonized either with his views above alluded to or with his professed agreement with Spinoza I am at a loss to understand. Yet that is the way with Haeckel; after landing us in a bog of contradictory concepts, in the next paragraph he shows us that his attribute of *Empfindung* (which I think we may translate as "unconscious perception," *vide op. cit.*, p. 131, last paragraph) gives rise to a truly fertile conception, namely, the conservation of mental energy, which in a much more restricted, and needless to say more explicit, form has been recently utilized by Dr. Jung in his *Contributions to Analytical Psychology*.

Turning now to the structure of substance as apprehended under the attribute *Materie,* we are told that it consists of atoms—probably not ultimately the atoms of the chemical elements as we know them, but primordial atomic masses—surrounded by an all-pervading ether. We are further told that the existence of this ether is no longer a hypothesis, but can be regarded as a fact (*op. cit.*, p. 136); and this despite the admission that hardly any two physicists were agreed on its properties. (It is hardly necessary to point out that as a result of purely *experimental* investigation we are now driven to conclude that the non-existence of the ether is at least as likely as its existence, *vide infra.*) Having thus assumed the certainty of the ether's existence, Haeckel then proceeds to show its function in the unitary scheme of nature in the following astounding piece of argumentation: "As is well known, optical and electrical events in the ether are closely connected with mechanical and chemical alteration of matter; the radiant heat of the former changes directly into the molecular heat or mechanical heat of the latter; gravitation can operate only by the ether acting as a medium for the attraction of the separated masses, since we can assume no action at a distance" (*op cit.*, p. 138). What is this but a tacit admission that since action at a distance is no explanation of an observed fact, we must endow some substance whose existence is "known as a fact," but of none of whose properties we have certain knowledge, with the occult power (no mechanism, even of a hypothetical kind, being known) of "acting as a medium for the attraction of the separated atoms"; that is, since there is no perceptible cause of gravitation, let us

assume an imperceptible one. And this from the philosopher who ridicules belief in a personal God as a redundant and untenable hypothesis!

When dealing with the application of the *Substanzbegriff* to the living world he is as usual on much safer ground: in no case, he urges, are we justified in assuming for the explanation of the varied activities of animals and plants any "forces" other than those liberated in the metabolism of complex carbon compounds, as rigorously conserved as those acting independently of living things; and this is equally true of the activities which in the higher animals and man we call "mental" or "spiritual": "We know of only one kind of natural forces in all natural phenomena" (*op. cit*, p. 140). This is a salutary warning, but it can hardly be regarded as a basis of a philosophic system until its purely negative value—that is, the absence of any verifiable concepts other than those elaborated by the physical sciences—can be supported by the positive evidence of a transformation of suitable materials under appropriate conditions into an organism having all the properties of life as we know it. Haeckel, of course, recognized this, and in his Altenburg address on monism explained it all in picturesque terms: "After the glowing sphere of the earth has cooled down to a certain degree, drops of fluid water precipitate themselves on the hardened crust of its surface—the first preliminary condition of organic life. Carbon atoms begin their organism-engendering activity, and unite with the other elements into plasma-combinations capable of growing." But does all this really amount to anything? Haeckel, I suppose, recognized this as purely speculative,

though the general tenor of the lecture gives the impression of approximate certainty; but even so, whoever saw carbon atoms possessed of "organ-engendering activity"? Anyone who has spent but a trifle of time trying to induce simple carbon compounds—let alone elementary carbon, which is wholly inert at the temperature of "liquid water"—to form more complex ones knows how much more readily it "engenders" carbon dioxide. And of what conceivable use is it to explain the origin of life by recourse to hypothetical materials "capable" of growth? Is not this "capability" just what is at issue? This shift is not only bad philosophy, but, what is much worse, bad chemistry as well.

Granted the validity of the *Substanzgesetz*, Haeckel then describes how the universe as we know it has arisen by the operation of the well-known laws of nature. Unfortunately his exposition is based largely on the Kant–Laplace cosmogony which, as we have seen (*vide supra*, pp. 212 f.), is now a discredited hypothesis so far as small-scale phenomena are concerned. This only shows the folly of basing a so-called philosophy on the inferences from scientific theories which, as Haeckel himself admitted (*Die Welträtsel*, p. 186), are indispensable only until such time as they become replaced by better ones.

The remainder of Haeckel's exposition of his monistic system is taken up with a polemic against the crude dualism of good and evil, Nature and God, the traditional views of creation out of nothing, and the follies and evils of religious corporations—with nearly all of which I find myself in hearty agreement. Detailed exposition and criticism would here be out of place.

Sufficient has been said to indicate the general scope of Haeckel's monism. Much, indeed, of a just and fertile nature has been omitted from this brief account; yet I have passed over nothing which is essential to an understanding of his main standpoint, and at the same time I hope I have adequately demonstrated that this standpoint, and the development of his views therefrom, were too full of contradictions for the realization of his ideal. But I shall not leave this matter without setting forth what I think are the lessons of permanent value to be derived from Haeckel's essay and its failure.

First, on the positive side, I think it will be agreed that Haeckel for the first time drew attention to the wonderful *convergence* of results in the different branches of science, providing a powerful indication of the unity of nature in itself, and of the far closer bonds by which man is held within its sphere, than had ever been demonstrated by direct recourse to observation and experiment; the deduction of Spinoza had in a remarkable measure been inductively verified.

In the next place we cannot deny that the *Substanzbegriff* is a valuable philosophic concept. It is only in its application that Haeckel goes sadly astray; and seeing that he was dealing with scientific coin coming hot from the mint, it is hardly a matter for wonder that he sometimes burnt himself, and sometimes passed a counterfeit.

Lastly, in his favour let it once more be emphasized that in appealing always for unbiased judgment he gave a wealth of illustration of how we may be constantly led astray by unconscious prejudices; prejudices which may in

the conscious mind be so transformed as to be unrecognizable. In this the modern world is far more indebted to him than it realizes.

On the other hand, we have had abundant proof that the attempt to solve the "Riddles of the Universe" by means of the results of positive science carries with it a far worse dogmatism than that of those ill-defined "metaphysicians" whom Haeckel heaps together in one "untouchable" band. Despite his optimistic statement that many of these riddles were in principle solved (*op. cit.*, p. 153), few men of science would now make any such claim. On the contrary, it is only by filling in wide gaps with highly speculative hypotheses that we can give any coherent materialistic *Weltanschauung*. And this speculation is by so much the more dangerous than that of the metaphysicians in that it leaves us in the hands of the experts. For, while any man endowed with a moderate share of intelligence, culture, and patience may fairly criticize a metaphysical system based on intuition, and developed according to the canons of sound reasoning, that same man must accept without question the so-called facts of science which are discovered and sponsored by specialists trained in minute observation and supplied with an armoury of elaborate instruments. Thus while he may be competent to judge whether *Cogito ergo sum* is, or is not, a valid piece of reasoning, it will generally be quite impossible for him to satisfy himself of the undoubted existence of isotopes. Fortunately for this cultured enquirer, matters of fact in science are usually adequately tested by rival schools of thought; but unfortunately for him, despite the undoubted integrity of the vast majority of men of

science, it cannot be denied that the world of science, like the world of politics, of letters, and of feminine allurement, is swept from time to time by fashions, from which, for a while, not even the most independent thinkers escape. Now these fashions, so long as they are recognized for what they are, namely, working hypotheses, do more good than harm; but let them be introduced into the texture of a *Weltanschauung* and their true character is at once lost sight of; they take on the aspect of concrete truths, from which there is no escape. Without them, indeed, a materialistic system is impossible; but with them it partakes of the same dogmatism as any philosophy of the schools.

There remains one further criticism of the most serious kind: that Haeckel is addicted to the dogmatism of "nothing but." His only means of escape from this censure is an unenviable one, namely, by the ambiguity of his terms. A quotation will illustrate this: "Our human body has been built up slowly and by degrees from a long series of vertebrate ancestors, and this is also true of our soul; as a function of our brain it has gradually been developed in reciprocal action and reaction with this its bodily organ. What we briefly designate as the 'human soul' is only the sum of our feeling, willing, and thinking—the sum of those physiological functions whose elementary organs are constituted by the microscopic ganglion-cells of our brain" (*Monism*, p. 40). Now it is difficult enough to understand how a "function" of a thing can "act and react" on the thing itself unless it is also a "function" of something else as well; but in the latter part of the quotation we are clearly informed that the soul is nothing but the sum of the

"functions" of the brain. Concerning the real crux of perception Haeckel merely states what he considers to be the facts without explaining them; thus: "Our naturalistic conception of psychic life sees in it, on the contrary, a sum-total of the phenomena of life, which, like all others, are bound up with a definite material substrate. We wish provisionally to designate this material basis of all psychic activity, *without which the latter is unthinkable,* as psychoplasma" (*Die Welträtsel,* pp. 55–6; italics my own). We may note in passing that *this* statement entirely nullifies Haeckel's claim for his philosophy that it is *not* materialism. For Haeckel, then, psychical activity is "unthinkable" without a material "basis" or "substrate." But he adduces no evidence beyond this statement of personal conviction. Unfortunately the opposite view, though by no means positively grounded by Berkeley, can certainly not be refuted. All our *knowledge* of nature is evidently *thought*; perhaps there *is* a material which thinks and external bodies which it thinks about, but we can never prove it. To many philosophers, from Spinoza onwards, it has appeared more profitable to consider "matter" and "thought" as inseparable correlates of one transaction. Now if this is what Haeckel really meant (and much of his writing indicates that he did), then he is confusing the issue by using the terms "basis" and "substrate." In the end we are driven back on our original view that Haeckel never sufficiently clarified his own opinions so as to determine precisely what he *did* mean.

We have now followed the history of monism as a philosophical concept down to the opening of the twentieth century;

and we have seen in what remarkable measure the results of natural science, which is bound to no philosophic pledge, illustrated, and in some measure verified, the bold intuition of the first Greek nature philosophers. But we have also seen that the lavish prodigality with which nature yielded up her secrets to the pertinacity of modern men of science turned their heads, so that they forgot the basis of their own discoveries—the power of selection and arrangement possessed by their own minds. This obstacle, the relation of thought to its objects, has been the careful study of speculative philosophers at least from the time of Socrates; but their failure to free themselves from dogmatic obsessions has made them the scorn of men of science. The failure of Haeckel's monism, however, in so far as it was due not merely to relatively unimportant errors in detail, but to a fundamental misconception as to the relations of the concepts and methods of science among themselves and with nature on the one hand, and thought in general on the other, clearly indicates that this problem of philosophers has to be reckoned with. Natural science is conceptual thinking; and, as Dr. Whitehead wisely points out, "Once you tamper with your basic concepts, philosophy is merely the marshalling of one main source of evidence, and cannot be neglected" (*Thc Principle of Relativity*, 1922, p. 6).

Our next task, therefore, will be to review these concepts in the light of modern epistemology.

PART III

THE DATA AND CONCEPTS OF NATURAL SCIENCE

CHAPTER XV

OUR KNOWLEDGE OF THE EXTERNAL WORLD

THE fundamental defect in Haeckel's method, which must inevitably have invalidated his conclusions, was his failure to recognize that the constructions of natural science, however unassailable within the limits of their own relevance, cease to have any rational status when pressed into service outside those limits. So long as natural science is content to restrict itself to statement of opinion which can be confirmed or rejected by appeal to experiment, it acts as its own regulator; but as soon as, with Haeckel, it passes beyond the realm of experimental method into that of speculation concerning the ultimate nature of things, it must be prepared to pass through the discipline of philosophy whereby it may be enabled by criticizing its own foundations to discover what, if any, may be the relevance of its knowledge to knowledge of the ultimate.

The first-fruits of this criticism, which had been going on contemporaneously with Haeckel's speculation, were somewhat unsatisfying. While agreeing with Haeckel that there is no means of knowledge except the experimental method of science, these critics emphatically denied that the knowledge so obtained could be of anything but phenomena—that is, of things as they appear to our consciousness. Indeed, they went further, averring that since all we are conscious of is our own conscious states—our knowledge is, in fact, confined to them; *something* in the world outside us

there must be, but of its real nature we know, and can know, nothing.

If this doctrine—generally known as phenomenalism—is true, the aim of this work is a vain one; for monism, as we have seen, is the belief that ultimate reality is in some sense *one*; but if no knowledge of this reality is possible, the whole discussion must be mere word-spinning. It is imperative, therefore, that before proceeding any further we assure ourselves that phenomenalism, though its analysis of the nature of scientific knowledge is illuminating, ultimately accepts a view which is not a necessary consequence of its premises, and whose falsity is revealed by the manifest absurdities that inevitably follow from it. And in so reassuring ourselves we shall have struck at the heart of the problem of just what knowledge science *can* give us about ultimate reality.

Let us examinine the evidence for this phenomenalist theory of knowledge. Without going too deeply into the problem of perception, we may, I think, put it this way. Every conscious subject is provided with a series of sense organs connected by means of afferent nerve fibres with a central nervous system. The acquisition of knowledge by this consciousness is limited to the incoming nerve currents and their interpretation by means of the inherited and acquired intelligence, built up partly by association of previously conjoined afferent impulses, and partly by the motor responses which these have called forth from the consciousness. I sense a red oblong; I perceive it to be a cylinder by virtue of kinaesthetic associations traceable to childhood; I infer it to be a pillar box because I have

probably never seen other red cylinders standing at street corners.

Thus far we have stated nothing that would not gain general assent from psychologists; but the next step is crucial. Nothing—neither pillar boxes, nor cylinders, nor even red patches—gets beyond our receptor organs. We have immediate awareness of nothing outside our own conscious states; everything else under heaven can be known only mediately through nerve currents—whatever these may be. At the peripheral ends of the nerve fibres likewise there are no objects, but only physical stimuli.

The theory of knowledge which follows from this account of perception had best be heard in the words of one of the leaders of this school, Professor Karl Pearson: "These sense-impressions we project, as it were, outwards, and term the real world outside ourselves. But the things-in-themselves which the sense-impressions symbolize, the 'reality,' as the metaphysicians wish to call it, at the other end of the nerve remains unknown and is unknowable. Reality of the external world lies for science and for us in form and colour and touch—sense-impressions as widely divergent from the thing 'at the other end of the nerve' as the sound of the telephone from the subscriber at the other end of the wire. We are cribbed and confined in this world of sense-impressions like the exchange clerk in his world of sounds, and not a step beyond can we get. As his world is conditioned and limited by his particular network of wires, so ours is conditioned by our nervous system, by our organs of sense. Their peculiarities determine what is the nature of the outside world which we construct" (*Grammar of Science*, p. 76).

At first sight this theory has a strong appeal to the scientific imagination, as it deals only with entities—brains, nerves, light, heat, etc.—which are the objects of scientific investigation; it postulates no "psychological" entities nor processes save consciousness and sensations, both of which certainly exist somewhere. But a moment's consideration shows us that this apparent immediacy of its apparatus is entirely illusory.

In the first place we have no immediate evidence for the existence of brains or nerves, but only of sense-impressions, *i.e.* greyish irregular lumps and white streaks—at least that is all the phenomenalists themselves allow us. Consequently our knowledge must be gained entirely by the impingement of one set of sense-impressions on another set, which sounds remarkably like nonsense. In other words, the psychological aspect of phenomenalism can be made to "work" only by the tacit assumption that however much the external world may be composed merely of "families" of sense-data (the expression is Mr. H. H. Price's, *vide Perception*, p. 282 *et seq.*), the perceiving apparatus is characterized by other features.

This inconsistency is made the more glaring when we take into account the epistemological aspect of the theory, namely, that the "thing at the other end of the nerve," which is unknowable, is "widely divergent" from our construct of it. Leaving aside the contradiction implied by the assertion that a thing which is unknowable is widely divergent from something else, we must in any case infer that were anyone's brain fortunate enough to perceive itself in the act of perceiving (a state of affairs involving no

contradiction) it would be in the humiliating position of perceiving itself as something widely divergent from what it in fact is!

Finally, as Mr. Price so clearly shows (*Perception*, pp. 290–1), though the theory of phenomenalism is almost certainly correct in asserting that what we call objects in the external world are families of sense-data, it asserts less than the truth by denying that these objects have any other knowable characteristics. One instance should substantiate this. Of a magnet in my pocket I have no sense-impressions; but I know that if I bring a suitable object of which I have such impressions, such as a compass needle, into the vicinity, I shall receive sense-impressions of the causal efficacy of the magnet by the deflection of the needle. Now even a phenomenalist would agree that causal efficacy must be exerted by *something* (whatever view we may take of the *nature of causation*), and in this case it cannot be by a family of sense-data, because there is not one, seeing that the family constitutive of the compass needle does not suffice by itself. From which we must conclude that there *are* physical objects in the external world whose existence is independent of the families of actual and obtainable sense-data which accompany them. It is, I take it, to this dual character of perception that Professor Whitehead refers when he speaks of the modes of presentational immediacy and of causal efficacy (*Process and Reality*, p. 170 *et seq.*).

Of course phenomenalism has not denied the *possibility* of the existence of "physical objects" independent of the families of sense-data, which, they assert, give us our *only* knowledge of the external world; it has merely affirmed

the belief that, since we can have no knowledge even of their existence, let alone of their character, we are merely wasting time in considering them at all. The view that I am urging is, on the other hand, that not only is it impossible to explain *all our experience* of the external world, unless there exist physical objects independent of the families of sense-data accompanying them, but further that we do have some knowledge of their character.

The attempt to give an answer to the query as to what that knowledge may be will occupy the greater part of the remainder of this book; but it will perhaps make for clarity if I at once remove a few doubts which may be lingering in the reader's mind.

In my view most of the existing confusion as to what is "mere appearance" and what, on the other hand, constitutes "reality" is due to a persistent failure to recognize that these are not mutually exclusive categories for any situation as a whole; anything which exists *at all* is *in some sense* real.

Thus appearances in the perceptual realm are merely contradictions in terms. The object elliptical-penny which I perceive when viewing it obliquely is not an appearance of a round penny; it is not an appearance of anything but an elliptical presentational object. The fact that it appears round when viewed normally is no "proof" that it is *really* round, and that when viewed obliquely *appears* elliptical. In the absence of any infallible guide to the contrary, there is equal justice in describing the perceptual penny as really elliptical but appearing in certain circumstances as circular. In other words, all perceptual objects are what they are.

and are not appearances of something else which is "really" different. If it be objected against this view that an object cannot at the same time be an infinite number of different things corresponding to all the possible appearances, I shall obstinately reply that in my view that is just precisely what it is; that is, returning to our penny, that it is not really a circle which may appear as a series of ellipses or even as a thin rectangle, but that it comprises in its actuality all the possible aspects, all equally real; each also, just in so far as it is not the totality of the penny, to that extent appearance. This view, at which I arrived independently, has been urged in various forms by Lord Russell, Sir Percy Nunn, and Professor Lossky.

It is important to distinguish here between the perceptual object and the physical object. Each perceptual object, which is constituted by all the sense-data appropriate to the particular aspect, is as "real" as any other perceptual object obtained from a different aspect and accompanying the same physical object; that is, the *physical* object is not an infinity of different objects *per se* (which would be the view of naïve realism), but is accompanied by an infinite number of perceptual objects, each of which *is* to a certain extent the physical object, *i.e.* it gives us knowledge of it, but the latter is much *more* than that.

We may conclude, therefore, that it is impossible to perceive all that is constitutive of a physical object, because we are restricted, from the nature of our sense organs, to one aspect at a time; and furthermore, to every physical object belongs more than the sum-total of the perceptual objects accompanying it. Now it is to the credit of phenomenalism

that in directing thought to the problem of the character of the object "at the other end of the nerve" it has been responsible for the recognition of the futility of enquiring what this object is *really* like *per se*. In other words, it has taught us to acknowledge that alone "as real which has a real effect" (Bernhard Bavink, *The Anatomy of Modern Science*, p. 29). Physical objects are real in so far as they react on other physical objects, and science can give us knowledge of them in so far as it reveals the nature of these effects. By what methods it seeks to do this and to what extent it can succeed in its aim we shall now enquire.

CHAPTER XVI

THE LAWS OF NATURE

THE first step in the attempt to give a scientific explanation of nature is to enunciate the "laws" pertaining to its several regions. Let us try to discover just what such laws really tell us.

I suppose no law of nature is more important in physics than Newton's first law of motion (actually first put forward by Galileo), which is now generally enunciated as follows: "Every body continues in its state of rest or of uniform motion in a straight line, unless it be compelled by impressed force to change that state" (W. Watson, *A Text Book of Physics*, p. 69). This is a statement of the *rest and motion* of *bodies* under the action of *forces*.

First, what is a "body"? A sufficiently good definition would be "any constant quantity of matter." Passing over the fact that it is highly improbable that any quantity of matter ever does remain *absolutely* constant (or how can we account for the faint but perceptible smell of metals?), we may further enquire what matter is. Matter, Descartes held, was that which fills space; this, of course, tells us neither what matter *is* nor how it differs from a limited region of space itself. The latter difficulty did not arise for Descartes, who *assumed* on metaphysical grounds the nonentity of empty space. Newton considerably improved the definition of matter by defining it as that which possesses inertia, inertia being further defined as that property which

requires a force to be applied to set the body in motion. We have now succeeded in accurately defining "bodies" in terms of "force."

We commonly define "force" as "that which moves or tends to move bodies." We do not, of course, delude ourselves into supposing that this tells us what forces are *per se*, but it is sufficiently accurate as a basis of dynamics, until we recognize that it contains the word "bodies." Since, then, we define "bodies" in terms of "forces" and *vice versa*, it is not surprising that we may actually be able to enunciate a "law" concerning their mutual reaction! Can we not, however, by making simplifying assumptions as to the intuitional basis of bodies and forces, found the law experimentally? Unfortunately even this is barred to us, since it is impossible to observe a body under the action of no forces; whatever we do with it, wherever we take it, it is still under the action of its own "weight." And yet we see bodies remaining stationary in apparent defiance of the law; this is explained by assuming the existence of an equal and opposite force. There is only one way out; and that is that when we gradually remove all those conditions which we recognize as opposing forces we approach more and more nearly to perpetual motion.

But we have not yet decided what motion is. Motion is displacement with respect to the observer; from which it would naturally follow that when I see the Waverley Station at Edinburgh glide away from me I must assume the operation of colossal forces to overcome its inertia. Yet when I get out of the train at King's Cross I am quite unjustifiably convinced that the train has moved and not

the whole of Great Britain. Why? I have no possible means in myself of discovering which of these displacements has occurred. Nevertheless, from the fact that trains going to Aberdeen were not carried back to Newcastle by the supposed coincidence of wheel-slip and continental drift, I might reasonably infer that it was only the train that moved. On the other hand, since Copernicus, the earth has been held to move round the sun, hence London and Edinburgh *did* move, after all; so motion and rest are purely relative terms unless referred to some frame of reference! Now the only way we can detect the incidence of an unbalanced force is by motion of some body, and the above discussion indicates that it must be clearly proved to be absolute motion, otherwise we may be demonstrating that the new force is acting in a direction opposite to its "true" one. In other words, we must seek for some absolute frame of reference, to which all other motions may be related; and, sad to tell, we are still seeking!

The first law of motion, then, upon which the whole of dynamics is based does not in strictness apply to individual bodies, but is a relation between certain conceptual entities—mass, force, and the like—which it thereby defines, though since it comprises a statement of physical fact which can be verified to a high degree of accuracy it is not a *mere* definition (*cf.* Max Planck, *General Dynamics*, pp. 11–12).

At the risk of being wearisome I must take another example of a law of science, not to adduce further evidence for the point which has been dealt with above, but to show that there are different kinds of laws. I shall take this time a law which may be ranked as purely empirical, if

any may, namely, the law of Robert Boyle, which says that "The volume of a mass of gas varies inversely as the pressure at constant temperature."

The volume means the space it takes up; unfortunately, a gas takes up any space you like to offer it, so we must confine it under some mercury.

We have already seen that the mass (or quantity of matter) of a body is inevitably bound up with the shifting categories of space and time, but as here we are dealing only with a constant mass its exact definition is unimportant. But when we pass on to "pressure" the question crops up in another form, for pressure is force per unit of area. Now according to another law (Pascal's) the force which a liquid exerts on unit area depends only on the vertical height; hence we may use a column of mercury as a measurable source of pressure *if* the liquid is incompressible (which is true only within the limits of experimental error), and if we can measure *vertically*, which we can do, again within limits. Now if we carry out the experiment too quickly we shall find the volume too great on increase of pressure, and too small on decrease. The presence of another prepared tube of mercury (a thermometer) will show us that temperature changes are involved, that is, changes in the intensity of that quality of the gas which gives us sensations of heat.

Finally, what is a "gas"? It is a quantity of matter which fills any space into which it is put; if it is under no pressure its volume becomes infinite, hence as matter it is virtually non-existent. If it is highly compressed it becomes denser than the corresponding liquid at ordinary pressures and

lower temperatures. When does it cease to be a gas in both directions? It is impossible to say; but it is quite certain that it ceases to "obey" Boyle's law in the latter case. Again, if we try different "kinds" of gases we find that they obey Boyle's law in various degrees. In other words, we find that Boyle's law is not a law at all, but a figment of the imagination (and also partly a fluke) .It is a figment because it deals with imaginary entities to which existing phenomena approximate within certain conditions, and it can inform us as to the behaviour of these ideal entities only by arbitrarily fixing all the conditions save one. Of course it is perfectly true that science can make no progress without this arbitrary simplication; and it is further true that having varied the conditions one at a time, and thus deduced the partial laws, we may then combine them into one mathematical process, by which we may, and do, accurately forecast what will be the *result* of their joint operation; but we must not then deceive ourselves into believing that this is an exact copy of what goes on in nature (*cf.* Russell, *The Scientific Outlook*, p. 72, published after the above was written).

We may conclude, therefore, that the so-called "laws of nature" are summaries of experience, having a high degree of probability, but expressed in terms of concepts obtained by abstraction of irrelevant features from perceptual objects. If they fail to yield to us the whole truth, they at least (*pace* the phenomenalists) *converge* to that truth by the refinement of instrumental precision and the gradual vindication (or otherwise) of the preliminary simplifying assumptions.

CHAPTER XVII

THE CONCEPTS OF SCIENCE

LAWS give us partial knowledge of perceptual objects; but the fact that the same laws are found to apply to the corresponding qualities of various entities indiscriminately prompts the man of science to seek some concept of a higher degree of abstractness, which may be made the basis of some "theory" as to the common "cause" (*vide* Chapter XVIII *infra*) of the phenomena.

On the traditional view a theory is an hypothesis of a high degree of generality, which is not only consistent with all the facts known about the group of phenomena it seeks to explain, but has also been successfully applied to the explanation, and even the prediction, of new facts and subsidiary hypotheses. By way of illustration let us consider the rival hypotheses concerning the nature of light, and let us try to determine precisely what is to be understood by the statement that the undulatory hypothesis was finally established as the correct *theory*, even though we may agree with Lord Russell that it is impossible to say just at what point an "hypothesis" becomes a "theory" (*Analysis of Matter*, Chap. XIX).

When views as to the nature of light first became sufficiently critical to be worthy of the term "hypotheses," the following "laws" had been experimentally established; (*i*) rectilinear propagation (Euclid) with finite velocity (Roemer); (*ii*) coplanar and equiangular reflection (Euclid);

(*iii*) coplanar and sine ratio refraction in isotropic media (Snell); (*iv*) refraction along two axes, one coplanar, the other not necessarily, with the incident axis, in anisotropic bodies (Bartholin); (*v*) the impenetrability of the anisotropic medium (in certain positions) to light transmitted along either of the axes mentioned above (Huygens); (*vi*) the formation of coloured fringes when light is reflected from two surfaces separated by a very small distance (Hooke, Newton); and the formation of similar fringes when a fine pencil of light strikes a very fine obstacle (Grimaldi–Newton); the distribution of the fringes in the former case being strictly correlated with the thickness of the plate; and (*vii*) the demonstration by Newton, amounting to proof, that white light consists of a mixture of lights of various refrangibilities, light between certain fixed limits of refrangibility always exciting a certain definite colour sensation.

Any hypothesis put forward to explain these phenomena had in the first place (from (*i*) above) to be concerned with something in motion. Now a material in uniform motion, whether it be conceived as atomic (Newton), or continuous (Huygens), can be made to account well enough for (*i*), (*ii*), (*iii*), (*vii*), but it cannot possibly do so for the remainder (*cf.*, however, Newton, *Opticks*, 4th edn., reprint, 1931, p. 339); and for this reason, namely, that interference fringes, double refraction, and polarization—to give the phenomena their modern names—all indicate a lack of homogeneity in the motion. This was recognized (in the case of the first-named) as clearly by Newton as by any of his contemporaries, though modern textbooks usually

fail to give him the credit for it; but there is no ambiguity in the following words: "Every ray of light in its passage through any refracting surface is put into a certain transient constitution or state which in the progress of the ray *returns at intervals*, and disposes the ray at every return to be easily transmitted through the next refracting surface, and between the returns to be easily reflected by it" (Newton, *op. cit.*, Prop. XII, p. 278; italics my own). It was unfortunate that Newton mistook obliteration for transmission (though the evidence seemed sufficiently convincing), but there can be no question that he recognizes that there may be at times, if not always, a periodicity *in the light ray*. (How near the guess of genius may come to subsequently demonstrated truth is shown by his further comments on the above proposition, *op. cit.*, pp. 280–1; see also Query 17, p. 348.)

When we come to consider polarization, we see once again the remarkable insight of Newton striking right home to the *essential* character of light thus revealed. Light, he says, if it act in this way, must have "sides" (*Opticks*, Query 26, p. 358 *et seq.*), that is, it must possess, or be capable of being made to possess, a rigid spatial orientation. This was interpreted later by Young and Fresnel, when the mechanics of elastic solids had been elucidated (mainly by the former) to mean that light waves, as waves, have two mutually perpendicular components of their motion: the uniform translational, and the harmonic in the plane of the wave front the existence of whose phases accounted for the phenomena of interference and diffraction. Now a pencil of such rays may be statistically homogeneous, being com-

posed of rays vibrating in all possible directions in this plane, but capable of being resolved into sets incompatible with penetration along a certain axis of an anistropic medium; that is to say, there will be birefringence and polarization in two mutually perpendicular planes.

Yet although Newton thus clearly grasped the periodicity and vectorial character of light rays, he regarded the existence of sharp shadows as precluding any sort of undulatory hypothesis for the light itself, which he tentatively suggested was made up of corpuscles; on the other hand, he actually offered as an explanation of the phenomena of thin plates the stirring up of "vibrations in what they act upon."

Through the unimaginativeness of lesser men, what for Newton was a bare suggestion hardened into a dogma throughout the remainder of the eighteenth century. In the early years of the nineteenth century Young and Fresnel revived and established the undulatory theory in a form which cleared away all anomalies. (For further details, see pp. 194 *supra*.) In 1850 Foucault's experiment was performed to settle once and for all the rival claims of the corpuscular and undulatory theories; the result, it was held, established the former and rejected the latter.

We have now arrived at the crucial point for which all our discussion of the rival views about the nature of light has been merely preparation. We are faced with two questions: first, Can a single experiment decide "once and for all" between two hypotheses? And second, What exactly did Foucault's experiment establish?

I think it will be readily conceded that no experiment

has ever had the appearance of deciding more finally between two hypotheses than that of Foucault; yet within the last few years the discredited Newtonian corpuscular hypothesis has been revived by physicists of the highest repute and balanced judgment. The hypothesis has apparently been raised from the dead. Speaking for myself, I believe in the resurrection of *dead* hypotheses no more than I do in that of *dead* bodies; on the contrary, I affirm that that which is "born again" has never died; in other words, the *experimentum crucis* of Foucault did not *kill* the Newtonian hypothesis, but merely removed a part which had undergone necrosis. The part of the hypothesis to which I refer is not the corpuscular part, with which the Foucault experiment had no relation, but that part of the hypothesis which insisted on a gravitational reaction between the particles of light and the particles of the refracting medium similar to that which Newton held to subsist between two particles of matter.

The above short analysis seems to have answered both the above questions; but there is yet more to be learned therefrom. In the first place we must note that not only did Foucault's experiment not "establish" the validity of the Fresnel–Young theory of light—for the modern hypothesis is certainly not merely an extension thereof—but it did not even repudiate *once and for all* the opposing hypothesis. Once again we must ask, What exactly *did* it do? The answer that I propose to give to this question will cast much light, though in particular terms, on the ultimate question as to the precise nature of scientific theories. It is as follows, namely, that the observed lower velocity in

denser media establishes once and for all the truth of those abstract generalities concerning the phenomena of light which demand this result and renders untenable those that are incompatible with it. Thus baldly stated it sounds remarkably like a sententious delivery of the obvious; but if it is the obvious, then it is only another of the many obvious truths, whose constant neglect has led men of science into the assertion of those final utterances whose ultimate modification has been alike the scorn and despair of philosophers.

I pass now to the generalization of this view, and set forth what I believe to be the status of scientific theories in the realm of knowledge.

In my view the aim of science is the complete explanation of nature. The notion of explanation involves the assumption of the category of causation (process) and that of coherence (concrete universal). The first step in explanation is to determine the common cause of individual facts; for example, the cause of the multi-coloured band formed by the passage of "white" light through a prism. This step probably demands abstraction, though the fact has not always been recognized. In the case cited, for instance, the hypothesis advanced by Newton involved the concept of refrangibility, the degree of bending of the axis of a ray of light as a result of passing from one medium to another of different optical density. Now, according to the views urged in the previous chapter, the law of refraction is a summary of relations between concepts. Light itself may be bare sensation; a *ray* of light belongs to an entirely different order of entities; no one has ever seen a ray of

light, nor ever will, for the excellent reason that rays are arbitrarily isolated regions of actual beams of light themselves perceptual objects. There is here no question of the validity of such isolation; but the fact remains that abstraction has crept in at the very first step in the correlation of phenomena. The verification of the hypothesis yielded knowledge which approximates so closely to immediate apprehension as to justify the use of the term "explanation." When this and the many other optical laws above-mentioned were subsumed under the theory of an undulating ether, the conceptualism becomes at once apparent. The ether is one of the many highly abstract generalities which science has found it convenient to invent in order to correlate several laws in the concisest manner, and also to provide the basis of a mechanism whereby their supposed common cause might be visualized.

It appears to me that an inadequate analysis of the nature of those conceptual entities by men of science has led to two erroneous conclusions. In the first place, their highly abstract nature having been overlooked, these conceptual entities have been regarded as the actual substance of the universe; thus by stripping experience of all its finer shades of colour and feeling, it was easy enough to prove that reality was "nothing but" oscillations of a primordial ether. As Professor Whitehead has said: "Clear-sighted men, of the sort who are so clearly wrong, now proclaimed that the secrets of the physical universe were finally disclosed. If only you ignored everything which refused to come into line, your powers of explanation were unlimited" (A. N. Whitehead, *Science and the Modern World*, p. 142). Opposed

to this view were thinkers like Ernst Mach, who in clearly recognizing the abstract nature of the entities assumed in scientific thought, denied to them any reality save as instruments for the economy of mental effort. Their status was therefore a purely pragmatic one: they served to extend the boundaries of knowledge of phenomena, and put into man's hand a powerful weapon for the control of these phenomena; but with any *ultimate* explanation of nature they had nothing to do.

The second of the above views has been espoused by various thinkers, each adopting some slight shade of difference in the interpretation of the relative reality of the two aspects of nature. That adopted by Mach has the virtue of consistency and methodological purity; a more insidious form is that in which it is maintained that we experience the real world, and the concepts of science are in Professor Whitehead's happy phrase "merely conceptual, yet they are an interesting and picturesque way of saying something else which is true of nature" (A. N. Whitehead, *The Concept of Nature*, p. 45). His manner of dealing with this duplicity is typical: he proceeds: "But surely if it is something else that you mean, for heaven's sake say it. Do away with this elaborate machinery of a conceptual nature which consists of assertions about things which don't exist in order to convey truths about things which do exist" (*op. cit.* p. 45). On the next page he delivers himself of a categorical assertion which, I believe, amounts to the same thing as the view which, with halting stride, I have been approaching in these pages. His words are as follows: "Thus the molecules and electrons of scientific theory are, as far as science has

correctly formulated its laws, each of them factors to be found in nature. The electrons are only hypothetical in so far as we are not quite certain that the electron theory is true" (*op. cit.*, p. 46).

It appears, therefore, that the theories of science deal with concepts of a high degree of abstractness in which are ignored, as irrelevant to the task science sets before itself, those aspects of natural objects which may be loosely described by the conveniently vague term of "values." Further, the concepts of science are always incomplete; or, as Professor Whitehead would say, inadequate. Thus particles of matter *do really* attract each other according to the inverse square law, *providing* we are careful to limit the significance of such *concepts* as "attraction." Or, which is perhaps a better example, the chemical elements are *really* composed of indivisible atoms whose union in relatively simple numbers and kinds constitutes the process by which all substances are produced; the rigorous *truth* of Dalton's atomic theory has not, while the adequacy alone has, been called in question by the more recent developments of atomic physics; "chemical atoms" and "physical atoms" are, as it were, equally real, and equally incomplete, descriptions of some underlying existent in nature.

Thus if the entities of science are conceptual, they are not "merely conceptual," or to put it another way, they are no more conceptual, except in degree and not in kind, than the so-called perceptual objects, such as "chair" and "sun" (*cf.* A. N. Whitehead, "Undoubtedly molecules and electrons are abstractions. But then so is Cleopatra's Needle"—*Con-*

cept of Nature, p. 171). An enlightened psychology might have guessed this long ago; indeed, I had a hazy suspicion, which Professor Whitehead's full investigation has adequately confirmed, that Locke had done so. To-day we can hold no other view if the relational view of knowledge is accepted. This leads us to the somewhat paradoxical inference that the more general a theory is, at the same time the more remote is it from immediate experience and yet the more "true."

One more characteristic of the theories of science is of the utmost consequence for clear thought. All theories, if and when they have passed through the mill of mathematical enunciation—and I accept Poincaré's view that mathematics can do no more than enunciate them (H. Poincaré, *Science and Hypothesis*, English trans., 1905, p. 211; see also Whitehead, *Science and the Modern World*, p. 79)—must be presented in terms of abstract residua, such as Newton's "solid, massy, hard, impenetrable, movable Particles" (Newton, *Opticks*, p. 400, *op. cit., supra*), and the "elastic fluid ethers" of the nineteenth century; these are all right in their way, but they are non-essential; and, when their analogical character, which changes with the fashions of the day, has been overlooked, grossly misleading. This is, I believe, a crude parallel attributed to theories in general of what Professor Whitehead calls, in respect of the "spatialization of objects," which was the major philosophic blunder of the seventeenth-century mechanization of nature, the "fallacy of misplaced concreteness," that is, in his own words, "the expression of more concrete facts under the guise of very abstract logical

constructions." (*Cf.* Lord Russell: "Ordinary language is totally unsuitable for expressing what physics really asserts since the words of everyday life are not sufficiently abstract. Only mathematics and mathematical logic can say as little as the physicist means to say"—*The Scientific Outlook*, p. 85). These constructions are our invaluable servants in the search for further abstract relations; but if, their highly abstract nature forgotten, they are incorporated into our *Weltanschauung* as concrete components thereof, they insidiously gain the mastery over us, driving us into the dogmatic assertion of manifest absurdities, which nevertheless remain to cloud our thought and multiply our doubts long after the theory which they served to establish has been sunk in some much wider scheme.

No man of science, not even excepting Newton, has, I believe, remained truer to this ideal of expressing only that which is essential in nature than he, the centenary of whose birth we have been celebrating this year (1931); and no words of mine could express my feelings half so well as these of a great contemporary: "The same spirit is found throughout his whole work. He throws into relief the essential, *i.e.* what is common to all theories; everything that suits only a particular theory is passed over almost in silence. The reader therefore finds himself in the presence of form nearly devoid of matter, which at first he is tempted to take as a fugitive and unassailable phantom. But the efforts he is thus compelled to make force him to think, and eventually he sees that there is often something rather artificial in the theoretical 'aggregates' which he once admired" (H. Poincaré, *op. cit.*, p. 224).

Time has more than justified this generous tribute to Maxwell's intellect; and in a half century which has seen the complete upheaval and reorientation of all traditional views on the structure of nature, Maxwell's theory has remained unassailed—indeed, from the very purity of its conceptions, unassailable.

CHAPTER XVIII

THE NOTION OF CAUSALITY AND THE VALIDITY OF INDUCTION

"Felix qui potuit rerum cognoscere causas."

In this famous passage Virgil congratulates Lucretius on being the discoverer of the "causes of things." This notion of cause and effect has been the pathway along which science has marched through the ages. Of its value as a methodological principle there can therefore be no question; but our present investigation is concerned always with the status and ultimate significance of science as a body of knowledge of the real. We have therefore to see to what extent, if any, causation is a necessary constituent of scientific thought; or, to put it another way, to determine what must be the limitations to be set upon this admittedly fertile principle, which is firmly woven into the fabric of our language, if it is not to land us in contradiction or circularity.

If we are concerned to give a definition of causation we can hardly do better than adopt that of F. H. Bradley, who says: "We may regard cause as an attempt to account rationally for change. A becomes B, and this alteration is felt not to be compatible with A. Here A would still be mere A, and, if it turns to something different, then something else is concerned. There must, in other words, be a reason for the change" (*Appearance and Reality*, 2nd edn., p. 54). This view may be supplemented by that of one of the few

men of science who have been able to write intelligently about the basis of scientific reasoning, J. F. W. Herschel, who wrote: "If everything were equally regular and periodical, and the succession of events liable to no change depending on our will, it may be doubted whether we should ever think of looking for causes" (*A Preliminary Discourse on the Study of Natural Philosophy*, Cabinet Cyclopaedia, 1831, p. 35). These two passages illustrate well the broad philosophic view (the cosmological perhaps we might call it) on the one hand, and the specialized or methodological view of the empirical sciences on the other. The former is coeval with the first daring speculations of the Milesians about the primordial ground of natural phenomena, and is the "cause" which Lucretius sought in the "seeds and first beginnings" which form the nature of things. But it was only the change of attitude expressed in the latter, and, as we have seen, the realization of the necessity for abstraction, which led to the manifold discoveries of modern science. We may say, then, not unjustly, that knowledge of nature has come by controlling her, and not, as is commonly thought, *vice versa* (*cf.* Lord Russell, "Scientific thought . . . is essentially power-thought. . . . Now power is a causal concept, and to obtain power over any given material one need only understand the causal laws to which it is subject"—*The Scientific Outlook*, p. 86). Since it is with the status of science that we are here concerned, we shall for the present confine our attention to the latter.

Although the recognition of the arbitrary control of the conditions of change (and this I take to be the essence of the empirical method) was necessary for the advancement

of natural knowledge, its association with the subjective element of voluntary effort had unfortunate consequences; for, as Herschel pointed out, rather naïvely as we should now think, in a later part of the same work, it led inevitably to the identification of "cause" with "force" (*op. cit.*, pp. 149–50). It is true that Herschel admits that the argument is by analogy; but analogy seldom remains the servant of reason; before we have had time to realize it, it usurps the position of reason itself, and as a master it is apt to lead us into a fool's paradise of ignorance from which it is all the more difficult to emerge by virtue of the apparent justice and simplicity of the first false step. Thus it is one thing to speak of my hand exerting a pull on a stone twirled on the end of a string; but it is another to state that the earth does a like service for the moon. True, it is a sound analogy—sound, because quantitatively parallel; further, without this flight of genius there would never have been the far-flung order of the Newtonian cosmogony. Indeed, to Newton himself it was never more than an analogy: as to the cause, "*Hypotheses non fingo.*" But within a century magnets were "attracting" magnets, electric charges "repelling" like charges; and for the vulgar, even to this day, it was the imperishable glory of Newton that he explained why an apple falls to the ground.

Thus science doth make fools of us all; at least, in so far as we accept the statement of some of its high-priests that it seeks to explain the causes of things. The opposite view is, of course, that of phenomenalism, which denies that science can give us any real knowledge, but serves only as a method for the economy of thought. This, however, ill

fits the agreed fact that science gives us power to foretell the course of nature with amazing accuracy, and it is difficult to see how from the study of *mere* appearances it can be possible to foretell the behaviour of nature, even if, as must be the case, what is foretold is, according to the same doctrine, also mere appearance. But, as Dr. Broad has wisely reminded us, you cannot dispose of anything by labelling it an "appearance" (*Scientific Thought*).

The question now arises as to whether we can reject phenomenalism, which, for the above reason, and for those more cogent reasons already urged (p. 266 *supra*), we feel bound to do, and at the same time escape the necessity for attributing to natural science the power of discovering causes? The answer to this query is in the negative, unless we are prepared to admit that the notion of cause is in itself contradictory, or, at best, appearance in the true sense (*cf.* p. 268). And this is just what we now propose to do.

By appearance in the true sense I mean an object of thought which to educated common sense appears to be real and self-consistent, but which by close analysis comes to be recognized as being defined in such a way as to embody inward contradiction. Of such a character I hope to be able to show the notion of causation to be.

When we come to analyse causation, we are not analysing an immediate presentation at all. On the contrary, the notion of "cause and effect" contains explicitly the notion of two objects and implicitly the lapse of time. We have already borrowed from F. H. Bradley a definition of cause; we shall place ourselves still further in his debt by briefly reviewing his estimate of its value. "A causal statement

may usually be put in the form 'A becomes B'; but if A is at first completely distinct from B, then its change into B is merely an inexplicable miracle. If, however, A and C changes to B, where C is a term included to render the transition intelligible, then C either does or does not make a difference to A: if it does, A is no longer A to start with, and the introduction of C invalid; if, on the other hand, it does not, the same problem crops up again and C is merely the first term in an infinite regress" (*Appearance and Reality*, p. 55). The notion of causation as involving change is therefore unintelligible, if not positively self-contradictory. Is there any way, then, in which the connotation of the term may be so restricted as to make it a valid instrument of thought? To this I would reply that the notion of *absolute* change must be summarily rejected; otherwise that of cause is one lying outside the realm of science, or even of any metaphysic which could be consistent with science (*cf.* quotation from Meyerson, p. 173 *supra*). Causation, then, is another of those abstract notions without which thought and the acquisition of knowledge are impossible, but which, once their abstract quality is forgotten, lead us into dogmatism and ultimately confusion.

If this result at first sight appears to be purely negative and thus to bring us back inevitably to the acceptance of phenomenalism, a closer study may perhaps convince us that this is not the case. We must, in fact, undertake the task foreshadowed at the beginning of this chapter, namely, the determination of the restrictions to be placed on the notion of causation whereby it may become an instrument of precision in the discovery of the nature of the real.

We may best accomplish this by first discovering what thought-process is actually at work when we search for the "cause" of a natural phenomenon; there must be some valid process, even if a superficial view has described it as being other than it is, else it could not have proved the valuable means of discovery, and perhaps even more valuable means of dissipating the mists of supernaturalism, that it has proved to be. Once again we find the matter most adequately put by Bradley: "Causation is no mere phenomenal sequence. It implies a principle felt in the succession of the elements; and that principle is a connection which cannot be presented. . . . To apprehend causation we must first distinguish the elements before they have come together. And thus we get to perceive what we call the 'conditions.' But these conditions, when asunder, are not yet the cause. To make the cause they must come together; and their union must set up that process of change which, when fixed artificially, we call the effect. Hence to know causation we must (*a*) first have the elements in ideal separation; we must (*b*) then ideally reconstruct their meeting, and from that (*c*) perceive the issuing change. But such a knowledge surely cannot come from presentation" (*Principles of Logic*, 2nd edn., p. 538).

The confusion seems to have arisen partly owing to an ambiguity in the term "causation," namely, as *process* of change and *reason* for change. It is the business of science to study the former, and this it does by determining the conditions for the actualization of pre-existing potentialities. Thus when we say that the elliptical orbit of a planet is "caused" by the force of attraction between it and the sun

varying inversely as the square of the distance between them, we mean that the attractive force is prior, not in time, but only as a logical condition. Given the one, then the other exists *simultaneously*; time has essentially nothing to do with the matter; it belongs "only to the content, and not to the form of the causal relationship" (*vide* Bernhard Bavink, *The Anatomy of Modern Science*, pp. 73–5).

If, however, we wish to learn the *reason* for these phenomena we must seek it not in the abstractions with which science deals and which can never be the reason for anything, but in some *res vera*. (*Cf.* Descartes, "For this reason, when we perceive any attribute, we therefore conclude that some existing thing or substance to which it may be attributed is necessarily present"—quoted by Professor Whitehead, *Process and Reality*, pp. 54–5). It must not, however, be supposed that science can tell us *nothing* about causation in the ontological sense (which is what phenomenalism asserts); on the contrary, our knowledge of ultimate reality depends upon what science *does* tell us; but it must be remembered that all it *can* ever give us is "scientific" knowledge, that is, knowledge of a high degree of abstractness.

If I have still failed to make quite clear what a man of science means, or in my view ought to mean, when he speaks of the cause of a phenomenon, I must ask the reader's indulgence for the time being, because the whole story cannot be told until we have more clearly grasped what is meant by time and change. And since these concepts have undergone radical reshaping consequent on the discoveries of modern physics, I shall defer their treatment to the Fourth Part (*vide infra*, p. 400).

Before drawing this part of our study to a close we must first take a glance at the logical processes whereby hypotheses are in the first place educed from the crude data of experience and subsequently verified or rejected by being applied to similar data. Of these processes there appear to be two; for though at one period in the history of science, or more particularly at one stage in the development of each of its branches, the emphasis may be placed on the inductive method, and at another the method of discovery seems to be wholly deductive, yet it is entirely improbable that any discovery worthy of the name of "scientific" has ever been, or will ever be, made without the interplay of these two methods. For however long may be the chain of pure deduction whereby a crude hypothesis is elaborated and reshaped into a far-reaching and adequate theory, it must have started with a major premise, itself necessarily either an induction or a derivative from previous inductions; and much more emphatically must it be tested over a wide field of observation before it can be accepted as "true." In the words of common sense it must "fit the facts." But on close examination these "facts" in the commonsense meaning of the term are found to be illusory. The general theory of relativity, one of the great masterpieces of deductive thought, in the light of common sense appears to be recondite nonsense, and would be treated as such even by those competent to judge, if it did not "fit the facts." But these so-called facts are not facts at all, but elaborate theoretical constructions. Take as an instance the observed shift of the spectrum of a star whose light has passed near a powerful gravitational field. There is not a "fact" in this sentence: "light," "spec-

trum," "star," "gravitational field" are all hypotheses when taken together. Let it be clearly understood that I do not at all deny that the ribbon of light which we call the spectrum is not at least to some extent a fact; and the same may be said of "star" regarded as a point of light in the sky, and "gravitation" as a conveniently vague and high-sounding name for the undoubted fact that if you drive a train across a precipice it will never reach the other side. But what I do assert is that these facts are facts only *once*; to assume that they remain facts when abstracted from their context of direct experience is hypothesis; to what extent it is hypothesis may be realized by recognizing that other "facts" lead us to suppose it not at all impossible that the "star" we are anxiously observing on Christmas Day may have burst or been smashed to fragments on the previous Midsummer Day. To assume that although α Centauri's body lies a-mouldering in the interstellar grave its radiation nevertheless goes marching on may quite well be true; but it is at present very far from being an observed "fact."

Science, then, is merely one of the great religions, because it is founded on faith; that is to say, belief in the truth of something which is not self-evident, but without which the whole fabric would perish. This postulate, that of uniform and necessary causation, was shown up in its true colours by Hume, and every subsequent attempt to white-wash it has only served to emphasize the ephemeral quality of this pigment and the solid permanence of that which Hume's sceptical scrubbing laid bare. So long as this postulate remains an undemonstrable article of faith, induction

will remain, as Lord Russell has recently said, "an unsolved problem of logic" (*The Scientific Outlook*, p. 78). So long as men of science are content to state the "laws" of nature in the form of generalizations of a high degree of *probability*, logicians can have no quarrel with them; but let them, like Mill, turn the whole argument inside out, and having used "particular laws of causation" (J. S. Mill, *A System of Logic*, Vol. II, p. 100) to "prove" the general law, raise the "canons of induction" to the level of rigid logical processes, and they will quite rightly receive the "talking to" that Mill received from Bradley, who further showed that the "canons," in that they start not from individuals but from universals, are not even inductive in the true sense (*Principles of Logic*, p. 358).

I shall make no attempt to seek a way round this difficulty; but in conclusion I would hazard the opinion that the threefold character of what is loosely called "induction" has not been sufficiently recognized. In my view, induction in the usual sense of the term is not merely a department of logic in the sense that deduction is; nor is it at all fair to regard it as the ugly sister of the latter. You can rigorously prove the three angles of a triangle to be equal to two right angles because, there being no triangles in nature, you can and do so frame your definitions and postulates as to make that result inevitable from the start. Deduction is a branch of logic which may save us from error but can never yield us any new truth. Induction, on the other hand, in so far as it is a branch of logic, might be described as "deductive probability," and by the refinement of the probability calculus may be made as rigorous as deduction pure and

simple (*cf.* W. S. Jevons, *The Principles of Science,* Chaps. XI and XII). As such it produces probable knowledge by simple enumeration. As soon as the probability comes to be regarded as certainty it is not logic but hypothesis, resting on the major hypothesis, or as it might now be justly termed theory, of universal and necessary causation. Because this fire burns and that fire burns, there can be no warrantable inference that all fire burns; but it is a convenient hypothesis whose use is amply justified not only in everyday life, but analogously in the pursuit of knowledge of the most recondite kind. The value of the hypothesis is thus mainly that it works; and the more frequently it is found to work, not only by a continuation of the process of enumeration, but also by virtue of the harmony discovered between the consequences deduced from it and from other hypotheses, the more likely is it to be truth. But knowledge conceived in uncertainty can never by any means be perfected into certainty. The quest for certainty is the quest for illusion. Once you pass from *cogito ergo sum* you pass into uncertainty. This, then, is the second aspect of induction, namely, that it is inseparably bound up with the problem of knowledge; it is no more illuminating to call induction the "scandal of logic" than it would be to call perception the scandal of physiology.

The third aspect has not been regarded as so fundamental, but I think comparative psychology may perhaps show that a study of it would cast much light upon the main problem. I refer to the *artist* in the great investigator. Millions of people had seen rainbows; thousands at least must have puzzled over the connection between the sun,

the raindrop, and the coloured bow; but why was it Newton alone who leapt to the induction that all such multi-coloured images are due to the varying powers of the components of sunlight to be bent in passing from one medium to another? It has nothing to do with keenness of eyesight, nor even with a superior knowledge of the principles of logic. It may be that the only answer we shall get to this question will be framed in terms of superiority of associative power, of the power to take what Professor Whitehead calls the "aeroplane flight" of discovery (*Process and Reality*, p. 5), and greater urgency of intellectual drive; but evidence is not lacking to show that at times we are in direct contact with reality; that knowledge, as it were, strikes us complete and concrete, and only because of the insufficiency of language are we compelled to dissect it and reassemble the parts along conventional lines. In this connection the following passage from Mozart's account of his own creative work is highly significant: "The piece is almost ready in my mind even when it is a long one, so that later I take it in at one glance, like a beautiful picture or handsome man, and hear it in my imagination, not consecutively as it has to be expressed, but as it were all together, as a whole." I am here indebted to Professor Lossky's work for confirming my own tentative speculations (*The World as an Organic Whole*, p. 83). (*Cf.* also Max Planck, *The Universe in the Light of Modern Physics*, p. 61).

I conclude, therefore, that a belief in the validity of induction is essential to the existence of science; that the validity consists in the fact that the assumpton works; and that the man of science need make no apology for

either the assumption or the pragmatic justification, as the philosopher has to do no less if he is to escape from a vague solipsism. In case I here lay myself open to the charge of thoroughgoing pragmatism, I reassert my view that the mere fact that a belief *does* work over a sufficiently wide field of experience is in itself a proof of its partaking of the nature of, though not being identical with, absolute truth.

PART IV

MONISTIC TENDENCIES IN THE TWENTIETH CENTURY

CHAPTER XIX

THE NATURE OF THE PROBLEM

At the present day it is generally agreed we are passing through a renaissance in affairs of the mind comparable to that which followed on the decay of the Middle Ages. The pulse of the modern world beats faster, and its emotions have been stirred deeper by the world war than was the case with the mediaeval world; consequently one generation has seen such a disruption of systems and sweeping away of conventional standards as in an earlier age would have been the work of more than a century. But we should take too superficial a view of the history of our times if we were to regard this renaissance as having been brought about by the war; cracks and fissures in every vault and corner of the old edifice had been sprung in the early years of this century; the shock of nations merely hastened its downfall.

In the realm of natural science, such landmarks as can be made out at all clearly were the publication of the *Origin of Species* and of the *Treatise on Electricity and Magnetism*, the extension by Crookes and others of the early observation by Faraday of the remarkable phenomena displayed by a gas rendered incandescent by the discharge of electricity through it, the discovery of radio-activity by Becquerel, and the negative result of the Michelson–Morley experiment on the velocity of light relative to the earth's motion.

It is significant that all the above events occurred before 1890; but with the exception of the first-named, which,

though it initiated an upheaval in social and political thought whose rumblings have only a little subsided even to-day, was the culmination of a movement in science, they were for some time treated either as curiosities of small importance, or as anomalies which further research would clear up. If this is not wholly true of Maxwell's great book, this work was certainly not recognized as marking the passing of the great era of Newtonian physics. But as soon as to the sensational happenings in the discharge tube were added the even more astounding behaviour of rays which had escaped from it, and the scintillations produced on screens in the vicinity of radium salts, then not only to the most discerning but to the rank and file of the army of science it became manifest that a new era had dawned, in which all accepted conceptions would have to be passed in review. By many it was feared that the old theories would have to be cast on the dust-heap, or at best relegated to the museum showcase. But nothing of the kind has happened; the foundations of the shrine of truth had been so well and truly laid that the new discoveries have enabled our latter-day builders to erect round the ancient columns a nobler edifice, in which the original parts are being brought into closer harmony. Nevertheless the concepts which were the materials of these earlier theories have in most cases been rejected as being too narrow, too crude, too concrete. In this breaking up of much ancient masonry the philosophic pickaxe has at last come into its own; and to twist a little the metaphor, that very pickaxe has been much sharpened by its impact on the hard surfaces of scientific fact.

Many wild tongues have been loosed, and this remark-

able scientific *Aufklärung* (enlightenment) that is upon us is hailed alternately as the freeing of man's soul from ancient prejudices whereby it may shoot up like a bubble from the slimy depths of a dank pond to the purer air above; and again as such a recrudescence of barbarism, evil-living, and irrational folly as the world has hardly before experienced. The fact that both these views are equally justifiable points to the ethical neutrality of science. Let the cobbler stick to his last, and the man of science to putting his own untidy house in order; if he will turn philosopher he must start from the beginning in all humility, cast aside the authority of his name, and he will less frequently give encouragement to those who are content to survey the outline of the universe between tea-time and the first cocktail.

I have permitted myself the above digression to show that the concluding part of this work will make no attempt to solve the riddle of the universe. This long-suffering entity must have passed the stage when man's attentions filled it with a pleasant sense of importance; the cartloads of "solutions" now being heaped upon it must fill it with an inexpressible weariness. On the other hand, man's universe is an altogether different place from the kaleidoscope of restless billiard balls it seemed to the much-abused Victorians. Wherefore, though I can see no good purpose gained in knocking together models of the universe like mass production motor-cars, to be scrapped after each annual meeting of the British Association, I recognize that the monistic interpretation of nature put forward by Haeckel, though on the one hand receiving abstract con-

firmation beyond the dreams of its founder, has on the other, and as it were in the moment of triumph, been shown to be laid on foundations which were rapidly disintegrating.

The problem before us, then, is no simple one, but both complex and multiple. We are to raise once again the ancient categories of matter, energy, and the like, and to determine how modern physics has modified and refined them, and displayed them as facets of a larger whole. We are to face again the ancient problem of matter and life, and determine to what extent its enunciation must be modified before it permits of the possibility of a solution. We cannot wholly avoid, I fear, the thorny wastes of disputation concerning the relation of body and mind. And at the end we must fairly answer the question as to whether any established truth stands in the way of viewing reality as a unity. Of the possibility of *proving* the justice of the monistic interpretation by the method of science we have in Part Three shown that there is none. Likewise to metaphysics do we concede no such power; for metaphysics, however much it will, cannot entirely ignore physics, now that the latter has taken unto itself the critique of the very fabric in which our experience is possible—space and time; and physics is so lost in its latest fairyland that another Newton must come, one in whose hands modern mathematics is more Ariel and less Puck, before any such demonstration may be even dreamed of.

To the consideration of tendencies alone, then, shall we apply ourselves.

CHAPTER XX

BEYOND MATTER

In our discussion of the unity of matter we saw that at the end of the nineteenth century, although certain phenomena indicated a genetic relationship between the chemical elements, there was no strong evidence to show that they were physically any the less unresolvable than the chemists had been compelled to admit. When the breakdown of the old views came, however, it was through the physics of the atom that a pathway was made. It is hardly an exaggeration to say that Dalton's atomic theory of chemical elements and their interaction remains fundamentally as true to-day as on the day of its promulgation: no substance, once clearly established as an element, ever breaks up by any of the means then and now recognized as coming within the purview of chemistry; nor does it react with other elements except according to the established quantitative laws of chemical action; that is, it behaves in such a way as can be described only by the assumption that chemical reaction occurs between discrete quanta of the various kinds of elementary matter.

The attack on the elements was not direct at all; no one particularly wanted to break up an element, much less an atom; but the conclusion that an actual disruption of atoms was being seen in the discharge tube was thrust upon physicists as the only possible explanation of the phenomena. It is to be noted that the disruption of atoms was envisaged long before that of elements.

As far back as 1870 Crookes showed that the cathode stream was able to drive a mica vane. Although no such phenomenon had ever been observed in the case of pure radiation, Hertz and others were loath to accept the possibility of a stream of material particles being propagated in rectilinear paths from the cathode. It was not long, however, before Schuster had shown (by measuring the deflection of the stream by a magnetic field) that the ratio of charge to mass was of the order of five hundred times the value to be expected on the assumption that the particles consisted merely of ions similar to those formed in electrolysis. There was still a natural reluctance to accept this result as settling the nature of the cathode stream. The matter was decided once for all by Sir J. J. Thomson, who stands out among the many brilliant workers of this time as the one in whom innate genius guided manipulative skill to the right conclusion; this he did by measuring the absolute charge and the charge-mass ratio for the same particles, namely, those produced by the impact of ultra-violet radiation on a zinc surface, particles whose charge-mass ratio was the same as that of the cathode rays. The fact that this ratio was independent of the nature of the gas and the electrodes in the discharge tube established beyond a doubt the presence of a substance common to all elements; but common only. There was here no proof that other substances were not mixed with these negatively charged "corpuscles," as Thomson at first called them. And indeed the evidence at first supported the latter view, since when Thomson and Wien investigated the charge-mass ratio of the positive rays, the other current bearers in the discharge tube, they found that in no case was

it larger than that characteristic of the hydrogen ion in electrolysis; in other words, on the assumption that the charge is the same, the mass of the positive particles is of the order of that of ordinary atoms; moreover, the charge-mass ratio, unlike that of the cathode particles, varies according to the nature of the residual gas in the tube.

So, as far as the elements are concerned, the "new physics" promised ill for a unitary theory of matter. On the other hand, the disruption of the atom—for that the corpuscles owed their appearance to nothing less could not be doubted—gave the hope that with more powerful methods, ensuring a more complete breakdown, a greater simplicity might be revealed.

The discovery which ultimately made possible the use of these more powerful methods was of the kind known as "accidental." Searching for a connection between fluorescence and the production of X-rays (between which we now believe there is no necessary connection) Becquerel discovered that crystals of uranium salts, unexcited by any external agency, could influence a protected photographic plate. Within a few years the inspired enthusiasm of Mme Curie had placed in the hands of physicists substances of far greater radioactive power, whose radiations were classified by Rutherford and others into (*i*) highly penetrating rays having the same charge-mass ratio as the cathode rays, (*ii*) feebly penetrating rays whose charge-mass ratio was constant, but different from any known substance, namely, twice that of the hydrogen ion, and (*iii*) rays of exceedingly great penetrating power identical with X-rays of surpassing hardness. From our point of view, however, the most

sensational discoveries were those made by Rutherford and Crookes in 1900. The former showed that the metal thorium yields an exceedingly dense gas which is also radioactive; the latter showed that by chemical means a new solid element could be obtained from uranium having enormously greater activity than the latter, which appeared to lose all its own in the process. Becquerel confirmed this, and showed that within a year the uranium had recovered, uranium X had lost, all its activity. Now uranium and thorium were recognized many years before the discovery of their radioactivity as definite chemical elements possessing definite atomic weights; hence the above facts clearly indicate the spontaneous change of one element into another. This is quantitatively verified by the fact that the activity is proportional to the mass of the *element* present, irrespective of how it is combined, and that the rate of decay is exponential, which in ordinary chemical reactions is true only with the spontaneous breaking up of molecules, hence must in this case, seeing that we are dealing with elements, be due to the disintegration of atoms. Once again the old ideas have broken down, but there is no new principle of construction to replace them.

The first clue to the solution of this problem of the common basis of the elements came with the full recognition of the nature of the rays of low penetrating power—the α-particles. That they were none other than atoms of helium carrying two positive charges instead of, as in the case of the β-particles, one negative was demonstrated by a number of workers using a variety of methods during the years 1903–9 (for details, see Buckley, *Short History of Physics*,

pp. 204, 205). It is significant that all three radioactive elements, possessing very different chemical affinities, namely, to barium, yttrium, and zirconium, give off helium particles during disintegration; we have here, then, for the first time a suggestion that it is a terrestrial element of definite chemical properties which is the common basis of the elements; on the other hand, this leaves out hydrogen, whose atom could hardly be constituted out of those of helium which are four times as heavy. As so often happens in the history of science, further progress was rendered possible only by following a side road which had at first no seeming connection with the problem: this was the development in the technique of the handling, and in the extensiveness of application, of X-rays.

The X-rays, unlike the positive and cathode streams, pass out of the tube; they have their origin wherever a cathode stream strikes a solid object. Their importance for us lies in their property (discovered by Barkla in 1903) of setting up secondary X-radiation on striking metallic plates. The secondary radiation is characteristic of the element from which it is given off, and is independent, within certain limits, of the exciting rays. On comparing the frequency of corresponding lines in the diffraction spectra of the X-radiation of the great majority of the known elements Moseley discovered that the square root of the frequency increases uniformly in passing up the scale from aluminium to gold. The integers obtained by including constants in the relationship are the so-called atomic numbers; and when the periodic table is rewritten with these as a basis all its anomalies vanish. There is something in the atoms of all

elements, then, upon which X-rays act: by the addition of one unit of which the transition from element to element is effected. Now Prout's law was based on the fact that the atomic weights of all the elements are *nearly* integral multiples of that of hydrogen; but the deviations lay outside the possible errors of experiment. Unfortunately Moseley could not measure the X-ray reflection spectra of gases; hence it was only by extrapolation that the atomic number of hydrogen could be inferred to be the unit; this would involve the assumption that no elements remained to be discovered whose atomic weights lay between 27 and 1 approximately. The reinstatement of Prout's law came from still another quarter.

Between 1911 and 1913 two independent lines of enquiry had established the existence of elements whose atoms, though all identical in chemical properties and by chemical methods indistinguishable, could be sorted into two or more classes characterized by differences in atomic weight. Soddy and Fajans were the first to discover this phenomenon among the radioactive elements, and they explained it as being due to the successive expulsion of an α- and two β-particles, which would reduce the atomic mass by 4 units (the mass of the α-particle) without altering the net charge on the nucleus; Soddy suggested the name "isotope" for such elements. Almost at the same time Aston, working with a modification of Thomson's apparatus, was able to show by means of the mass spectrograph obtained thereby that neon's atomic weight of 20·2 was really only the average relative mass of an unequal number of atoms of masses 20 and 22 exactly. Here clearly was to be found the direct

means of establishing Prout's hypothesis as an accurate quantitative law. Indeed, the subsequent results obtained by Aston clearly indicate (on no assumption save that of the validity of the laws of electro-dynamics applied to charged atoms instead of to current-bearing conductors) that the relative masses of the atoms of all elements are integral multiples of *one-sixteenth part of that of the atom of oxygen taken as* 16 *exactly*. Now this is not Prout's hypothesis, since the atomic weight of hydrogen with respect to that of oxygen (= 16 exactly) has been shown by numerous investigators to differ from unity by a greater amount than could possibly be due to experimental error. For a time this appeared to be an anomaly; an account of its solution must for the moment be deferred (*vide* p. 317 *infra*), since to fix our ideas it is desirable that we should be able to refer them to a definite theory of atomic structure; in fact, in using the term "nucleus" we have already anticipated it. It was supplied by Rutherford.

The experiments on which his theory was based were singularly unambiguous in their significance, which was that if the atoms of an ordinary gas are bombarded with a salvo of high-speed particles of mass and size comparable with the atoms in the space, the chances are enormously against a direct hit. There can be but one interpretation of this result, namely, that a vessel of gas is largely empty space. The same is true of a sheet of gold-leaf. Now it had been definitely established that the atoms of all elements examined contained electrons, which are "corpuscles" of very small mass and unit negative charge. Rutherford's experiments showed that when a direct hit occurred it was always sig-

nalized by a powerful repulsion; now his "shells" were positively charged, therefore, by the known reaction between like charges, we may definitely infer that there exists in the atom a central core positively charged, which occupies but an infinitesimal proportion of the whole volume of the atom. Further, the magnitude of the charge on this nucleus was accurately measured in the case of several heavy metals, and found to be numerically equivalent to the atomic number derived from Moseley's law. Lastly, it is known that electrons may be disengaged from atoms by very mild shocks (*e.g.* a beam of light), and also that a definite minimum "ionizing potential" is required before any drift of atoms (thus converted into ions) occurs towards the electrodes. From the first fact we infer that the electrons are distant from the nucleus and scattered; from the second that the atom as a whole is electrically neutral. From all the foregoing evidence it may, I think, be asserted that the atom does in fact consist of a central positive nucleus of relatively large mass and minute volume, surrounded at relatively huge distances by a number of electrons equal to the positive charge on the nucleus. By stating this to be a "fact" I mean that it involves no more admixture of hypothesis than any statement of so highly abstract a character must involve. The rest of the Rutherford theory of atomic structure falls into two parts, namely, that which is concerned with the fine structure of the nucleus, and that which deals with the mechanism of the circumnuclear electrons. The former is no more a fact than J. J. Thomson's now obsolete "corpuscular theory of atoms" (set forth in his *Electricity and Matter*, Chap. IV), but there is a strong

matter of fact that in recent years it has been first modified and elaborated by Bohr, only to be finally rejected as being no more than a rough sketch of the real state of affairs.

That the nucleus exists, then, may be taken as fact; but the evidence concerning its fine structure is partly indirect, if not indeed merely negative. The first question is naturally whether the positively charged part of the atom is always made up of discrete units, constant in magnitude. The answer to this question may be sought along several lines of enquiry, the results of which are not wholly in agreement, at any rate superficially. In the first place, the only elements whose nuclei spontaneously break up into smaller fragments discharge particles whose mass is 4 units of atomic weight and charge 2 units. No smaller "positive" particles are ever produced by "natural" means. On the other hand, the mass spectrograph indicates for the lighter of the two hydrogen isotopes a mass of 1·0078 and a charge of 1. No smaller particles with positive charge have ever been produced by any means whatsoever.[1] It is natural to suppose, then, that the hydrogen ion (or proton) is the unit positive charge. It is a strange fact that while the radio-elements discharge unit negative charges, they never, so far as we know, release unit positive ones. But the existence of the hydrogen ion is too well authenticated to admit of any doubt that it is at least nearer to being the ultimate unit than is the α-particle. As Professor G. P. Thomson says: "The evidence that the proton is indeed the proper unit to choose is largely negative. No positively charged body has been obtained with smaller mass, and no one has

[1] The recent discovery of the "position" renders this statement inexact. The general argument, however, remains unaffected.

ever succeeded in removing more than one electron from a hydrogen atom. If the hydrogen atom really contains only one electron, then the residue after it is removed will be a body with a positive charge numerically equal to that of the electron, and thus it is probably the unit we are seeking" (G. P. Thomson, *The Atom*, Home University Library, 1930, p. 65).

An even stranger fact is that the α-particle with charge only twice that of the proton has a mass roughly four times as great; and further, that the atomic numbers (*i.e.* positive charge on the nucleus) of nearly all elements are in the same order as the atomic weights, but in no case is their value more than half that of the latter. These facts led to the next assumption regarding the fine structure of the nucleus, namely, that hydrogen alone has a nucleus consisting of unaccompanied protons, the nuclei of all other atoms being composed of sufficient protons to make up the atomic weight (approximately), together with enough electrons to reduce the *net* positive charge to the numerical equivalent of the atomic number. It is difficult if not impossible to give direct proof of this assumption; but it is rendered plausible by the difficulty of believing that a number of protons could remain packed together within a small space unless a comparable number of electrons were interspersed to hold them together by balancing their mutual repulsions by attractions. Moreover, it gives an exact interpretation of the nature of isotopes, whose formation in the case of the radio-elements can virtually be observed to be taking place by the very mechanism that is here assumed (*vide* p. 312 *supra*).

Only one difficulty remained before Prout's vague guess could be reissued as one of the fundamental theories concerning the structure of the material universe[1]: this was the fact that the four protons appeared to have to pass through a course of "slimming" before they could settle down with the two cementing electrons as the nucleus of a helium atom, the precise amount of "flesh" to be got rid of being $4 \times 1{\cdot}0078 - 4{\cdot}00 = 0{\cdot}0312$ units of atomic weight. Such a loss of mass was quite outside the range of experimental error; and a similar loss is involved in the construction of every atom, not only of helium. Now either we must assume that the hydrogen proton is different from those found in the atoms of all other elements, or we must assume that, since mass is very closely bound up with positive electricity, it may possibly alter when that positive electricity passes from a state of freedom into one of exceedingly intimate relation with other electric charges. Such an assumption was naturally repugnant to those who regarded the conservation of mass as an unassailable dogma; but they had only to turn their glance towards any piece of radioactive material to realize that part at least of the conservation dogma was quite literally exploded. This assumption was therefore made. That it has been amply justified, and in fact turned out to be the strongest evidence for the nuclear atom, will be shown at a later stage (p. 331).

[1] It is, however, not strictly true to say that *hydrogen atoms* are the bricks out of which the remainder are made. The proton is indistinguishable from the hydrogen *ion*; but the hydrogen *ion* is no more *hydrogen* (which the atom *is*) than sodium ion is sodium; in the case of the last-named the chemical properties are profoundly different.

If the modern views as to the nature of matter set out above are true, namely, that all matter whatsoever consists only of two constituents in varying configurations, it should not be inherently impossible to convert one of the so-called elements into another. This final stage in the revolution of ideas was realized by Rutherford in 1923. By bombarding nitrogen atoms with high-speed α-particles he obtained unquestionable evidence of the production of protons disengaged from the former; these protons, on their inevitable gain of electrons, would become hydrogen atoms; it was at first supposed that the nitrogen residues would have thereby lost 1 unit of atomic weight, but examination of the tracks showed that the impinging α-particle had been absorbed, whereby it may be inferred that the nitrogen had gained 3 units on the transaction, and would therefore correspond to an isotope of oxygen of atomic weight 17. Since this phenomenal achievement many others of a like character have been realized; and, what is more, the use of α-particles has been replaced by ordinary hydrogen ions accelerated (in the experiments of Cockcroft and Walton) by an electric field of half a million volts.

We may now sum up the modern view on the nature of matter. We have seen in earlier chapters that the concept of matter would not bear close analysis from the philosophical point of view, and that its definition involves circularity unless force can be defined, which is possible only if we can define matter. Nevertheless we know quite well what we *mean* when we speak of matter in the chemical sense; it corresponds to *something* real even if other ideas have been added to it which have involved contradiction.

Now matter in the chemical sense appeared to be composed of about ninety ultimate substances, which fact would have rendered any monistic interpretation of nature impossible—impossible, that is, unless as in the case of Spinoza's "infinite attributes" there exists for them *some* common system of relations. But the resources of modern physical investigation have shown that these forms of matter, ultimate so far as chemical reactions are concerned, are composed of not more than two distinct entities arranged in various proportions and relative positions, *and that so far as can at present be determined these entities are indistinguishable from what previously had been considered to be merely energy*. We should be false to our own principles of interpretation if we were to deduce from this that matter is only an "appearance" of energy which is the only "reality" in physics, and this for three reasons: namely, that we wish most sedulously to avoid the use of "bifurcation" theories; that we have as yet arrived at no clear and distinct idea of what energy ultimately *is*; and above all that these entities which lie at the basis of matter possess the one abstract quality—mass—by which alone we can distinguish, or think we can distinguish, matter. That this dualism within the material realm is not essentially unresolvable we may infer from the fact that one of our leading mathematical physicists has made speculative proposals for its removal (Dirac, *Nature*, October 18, 1930, p. 605).

CHAPTER XXI

BEYOND ENERGY

It was in the manifestations of energy that at the end of the nineteenth century we saw most hope for a monistic interpretation of nature. Heat, light, sound, electricity, and magnetism, at least in their radiant aspects, which could be clearly shown to be closely related to all their other forms, were adequately described as undulations either in materials such as air, or in the immaterial ether; the variation in their qualities was correlated with their differences of frequency. At the close of the century two other at first mysterious radiations—the X-rays and γ-rays—were brought into line. Moreover, though gravitation still remained a mystery, it was known that when any mechanical work was done on a body, that fraction of it which did not appear as potential or kinetic energy could be measured as heat or sound (that is, in the case of heat, as an indiscriminate increase in the kinetic energy of the individual particles of the body); and that heat and electricity were interconvertible in strict quantitative ratio. On the basis of all these observations the great principle of conservation of energy was erected, which in effect stated that the form of energy could be changed at will, but its amount, in a closed system, never; with regard to the change of form there was a proviso that a closed system could in no wise be disposed so that the *available* energy of any part increased in amount. This proviso was established at first as the "second law of thermodynamics,"

which was concerned merely with heat exchange; but it was afterwards extended to cover all the forms of energy.

Now not only have the different forms of energy been reduced to one, but, if we are to take quite literally the statements of some of our leading physicists, matter also is reducible to energy, for, we are told, a "scientific table is mostly emptiness; sparsely scattered in that emptiness are numerous electric charges rushing about with great speed" (A. S. Eddington, *The Nature of the Physical World*, Introduction, p. xii). But is it really "reducible" at all? Granted that we have conceived matter in too coarse a fashion, is it nevertheless true that matter is "nothing but" electric charges in motion? Before we can accept this statement we must be fully acquainted with all that the term "electric charge" connotes; and it is just because the audience to which these and similar dicta have been addressed have no such specialized knowledge that they have been the cause of much vain and misleading speculation. Surely it is pertinent to enquire why, when these charges one and all are known to possess inertia, which was and is the diagnostic quality of matter and certainly was never dreamed of in the original conception of electric charge—why in these circumstances it should not be equally correct to say that electricity is "nothing but" particles of matter split into two? This has the advantage of "explaining" the less in terms of the more familiar. It is the old story of a gradual change creeping over the connotation of terms without anyone realizing it. If you are going to say that matter consists of nothing but electric charges you must make it quite clear that *your* electric charges have properties that

Coulomb would have strongly denied or at which even Faraday would have opened enquiringly his kindly eyes. You must further point out that your positive charge is miraculously endowed with nearly two thousand times the mass of the negative; so that if, as has been said, the latter is merely a "naked" charge, the former must be troubled with chills; in other words, it cannot be *merely* an electric charge at all.

So matter turns out not to be *merely* a form of energy, unless by energy is meant something rather different from what the founders of the concept meant. But here, perhaps, it is apposite to enquire what exactly *was* meant by energy in classical mechanics. "Energy," Maxwell says, "is the capacity of doing work," and "Work is the act of producing a change of configuration in a system in opposition to a force which resists that change" (*Matter and Motion*, S.P.C.K. edn., 1920, p. 54). So we are up against our old difficulty of force with the additional one of configuration; for it must be clearly understood that the mere operation of a force does not of itself amount to the performance of work; on the other hand, the body so acted upon does by virtue of its increased velocity acquire the power of doing work; this power is called kinetic energy. If there is a force, *e.g.* gravity, resisting the effort which is tending to increase the body's velocity; then the velocity may suffer no increase, but the "using up" of the force *always* appears in some capacity for doing other work either as energy of configuration ("potential"), or as heat, etc. If all these "capacities" are converted into terms of force they will be found within the limits of experimental error to be equivalent to the

product of the original force and the distance through which it moved the body along the line of its own direction. This product, which is the mathematical expression of "work done," can by application of the second law of motion and the fourth kinematic equation be shown to be precisely equivalent to half the product of the mass of the body moved and the square of its velocity acquired by falling freely through the distance it had been previously raised. Thus the capacity for doing work possessed by a raised body depends upon the gravitational "tension." In the same way the capacity possessed by gunpowder depends on what may be called chemical or molecular stress, which on being "released" passes into increased kinetic energy of the molecules. But a difficulty here arises which is fundamental for the whole energy principle, namely, that it is quite impossible to say by mere inspection what may be the difference in potential energy between a gramme of manganese dioxide and that of an equal weight of the apparently identical substance gunpowder: experiment alone can decide. Further, the potential energy of wet gunpowder is quite different from what it would be when dry; as energy must be used to dry it before its potential energy is capable of release by trigger action. We can therefore give no definition of potential energy which shall be applicable precisely to all forms. And when we study the principle of relativity we shall find that it is quite impossible to define kinetic energy quantitatively except in relation to an arbitrary frame of reference. What, for instance, is the kinetic energy of an oak tree growing immeasurably slowly? Zero, as far as anyone on the earth is concerned, and yet it is travelling at a velocity

of several miles per second with respect to the "fixed" stars.

The principle of energy is therefore of incalculable value as a guide in the interpretation of experimental data, but of doubtful validity as a basis of any naturalistic metaphysic, or even, without a certain ambiguity, as a basis of physics. This uncertainty was somewhat sceptically put by Poincaré in a famous passage, which can hardly be too often quoted: "Of the principle of the conservation of energy there is nothing left then but an enunciation: *There is something which remains constant.* In this form it, in its turn, is outside the bounds of experiment and reduced to a kind of tautology. It is clear that if the world is governed by laws there will be quantities which remain constant. Like Newton's laws and for an analogous reason, the principle of the conservation of energy, being based on experiment, can no longer be invalidated by it." The passage itself is somewhat obscure; probably what is meant is that, like Newton's laws, which are *definitions* (though not *mere* definitions!) founded on experiment, the conservation principle really is only the definition of energy: whatever is conserved is to be regarded as energy (H. Poincaré, *Science and Hypothesis*, trans., pp. 127, 128). Maxwell, less ironic than the distinguished Frenchman, has nevertheless something of the same kind to say: "In fact we find that it is only by experiment that we can ascertain the form of the relation between the configuration of a system and its potential energy" (*Matter and Motion*, p. 68; *vide* also p. 66: "The nature of the connection between configuration and force remains as mysterious as ever").

The principle of energy has been subjected to buffetings no less violent than that of material substance. But although bruised and altered in shape, indeed in one respect actually sundered into two apparently contradictory forms, it has emerged triumphant in a fundamental way that matter, even if not so completely dead as the physicists suggest, has failed to do. One reason for this is, I think, that so long as force was considered to be the primary cause of activity, and work something that forces "do," matter had to be retained as the stuff "on" which the work could be "done." At the same time kinetic energy was naturally regarded as the "real" energy, and those systems which could be made to yield kinetic energy or to perform an equivalent amount of work were all lumped together into a mystical assemblage of those "possessing" potential energy. Already before the downfall of classical physics the primacy of force had been replaced by that of work or energy—for they, after all, are only opposite aspects of the same transaction—but since the advent of relativity it has been recognized that not kinetic energy, nor yet potential *energy*, but the idea of potential itself has become the fundamental aspect of the universe. (I should like very much to quote here Professor Planck's most illuminating remarks on the subject, but space forbids. See *The Universe in the Light of Modern Physics*, pp. 68, 69.) Nor does energy in the classical sense *seem* to be conserved *as such*; there is a time factor involved; though that this involves any necessity for rejecting the conservation principle seems not merely unlikely, but, as has been suggested above, impossible.

For the rest of this chapter we shall be concerned with

an attempt to determine what are the monistic tendencies, if any, inherent in the new physical synthesis of matter and energy brought about by the theory of relativity; and to enquire to what extent these must be modified by the apparently contradictory views which the quantum theory at first seemed to involve.

I am faced at the outset of this discussion with two fundamental difficulties. In the first place the mathematical processes whereby these theories have been established are a closed book to me: I must therefore accept the results without question. That in itself would not be so serious if it were not for the fact that the mathematical development has gone so far ahead of basic criticism of the concepts that the results have been translated into language which is utterly misleading. I venture to suggest, therefore, that any positive statements made by the would-be philosopher should be based only on those parts of these new theories which have been adequately criticized and verified, and which, moreover, have been put into a form reasonably complete and self-consistent. The second difficulty is that this book has already swollen to proportions far beyond those originally contemplated by the author; it is therefore quite impossible to deal at all adequately with the structure of these theories; any attempt at expository treatment must be eschewed. While a monograph on the philosophy of science, completed in 1933, which omitted all reference to these theories, would quite rightly be regarded with suspicion, at the same time I must urge my belief that it is at present impossible for anyone, even though he possessed the knowledge and skill, to base any sound and lasting

philosophic views on scientific theories which are still sufficiently new to be expounded and embroidered by leading men of science with a gift for journalism. So brilliantly have some of these works been executed that they have been incorporated into the literature of the subject. The exchange of views thus made possible between the specialist and the cultured public is all to the good in the long run; but at the time it envelopes the subject in a fog of words through which it is difficult to perceive just what is of solid, lasting masonry and what is plaster ornament.

The principal aspects of the theory of relativity which have a bearing on our immediate problem are as follows: the relation of matter to energy, the transformation of gravitation, and the exact nature of the space-time continuum.

We have already seen (p. 317 *supra*) that there occurs a curious disappearance of mass when four hydrogen nuclei are brought into intimate union as a helium nucleus; now, since this union has never been experimentally effected with any degree of certainty, we could save the principle of conservation of mass by assuming that the protons in helium differed qualitatively from those of hydrogen; but since the principle has broken down in another case where large production of energy is involved (radioactive transformation), it is at least worth enquiring whether the principle of conservation of mass is not really a special case of that of energy, or rather whether we may have to accept an even more drastic interpretation of Poincaré's dictum than he would have looked for. "Something is conserved": sometimes it appears as mass, sometimes as energy.

Already at the turn of the century, on theoretical grounds, it was recognized that a fast-moving electron ought to have a greater mass than a slower one. This follows from the fact that a moving charge generates a magnetic field, which involves energy. Now the only energy in a vacuum containing a moving electron is the latter's total energy, which expressed in the usual form for kinetic energy can be shown to be equivalent to that of a particle moving with the same velocity but having a mass greater than that of the stationary electron (J. J. Thomson, *Electricity and Matter*, pp. 20–22); further, when the velocity is no longer negligible compared with that of light, the mass increases with the velocity (*op. cit.*, pp. 44, 45). This prophecy was confirmed by Kaufmann's measurements of the charge-mass ratio for high-speed β-particles.

Now the negative result of the Michelson–Morley experiment had been "explained away" by Lorentz, by the assumption that matter suffers a longitudinal contraction (the contraction was first suggested by Fitzgerald) when it is held with its axis in the direction of the earth's motion, this explanation being less arbitrary than it at first appears, if we further assume the truth of Lorentz's theory of the electronic constitution of all matter. This interpretation of the absence of any observed relative motion with respect to the ether (that is to say, relative to the "absolute" frame of reference assumed by Newton; whether this is objectified by a hypothetical ether or not is immaterial) was shown by Einstein to be in effect an inversion of the actual relationships, resting as it did upon a somewhat hypothetical structure derived from classical mechanics. He replaced

it by a complete reversal of conventional views, and thus ushered in an era which differs no less from the Copernican than did the latter from the Aristotelian. He accepted the Michelson–Morley result, not as an inconvenient obstacle to further unification, but as a simple fact, proving the logical insufficiency of our views on space and time. Putting it another way, if the whole realm of terrestrial phenomena dealt with by mechanics can be accurately summarized in laws which are independent of the changing motion of the earth through space, but on the other hand certain optical and electrodynamic laws are found to alter when the axes of reference are moved, it is highly probable that there is no such thing as a unique rigid axis: that is to say, there can be no such thing as *the* length of a rod, but only *a* length as seen by a particular observer. Now those phenomena which have cast doubt upon the validity of the restricted principle of relativity have one property in common, namely, very high velocity with respect to the observer; it may be, then, that the discrepancy (with regard to the relativity principle) may everywhere exist, but only become observable when the velocity of the systems approaches that velocity by which all lengths are necessarily measured, namely, of light.

On the results of a masterly analysis of the relational nature of space and time to each observer, Einstein calculated the transformations which must be carried through for the co-ordinates of any body referred to one set of axes so that when viewed from a point referred to another set of axes in uniform rectilinear motion with respect to the former the laws of nature may retain the same form: these equations

proved to be identical with those of Lorentz derived from quite different presuppositions. But whereas Lorentz had shown that the mass and energy of a moving electric charge must vary with the motion, Einstein was able to deduce it as a general property of all matter consequent on the necessity of transformation for relative motion. With this demonstration the old distinction between mass and energy broke down: the mass is merely the "bound" energy measured in different units to simplify calculation. This point is of importance for our discussion, so will be considered in a little more detail. Actually the change of mass cannot be directly inferred from the transformation; it arises from the fact that when a collision between two bodies is viewed from two reference frames in uniform relative motion to one another it is impossible for observers on *both* frames to regard the total momentum after collision as the same as what it was before. It is no use saying that the masses remain the same, and the velocities are "really" such as would correspond to conservation of momentum but "appear" different to one of the observers; for that there is a "real," *i.e.* unique, frame of reference is just the very assumption which the relativity theory denies. One way out of the difficulty is to convert the velocities into displacement per lapse of "interval"; but for practical purposes it is desirable to retain the concept of velocity unchanged; this being so there is no option but to recognize the mass as a variable dependent on the spatio-temporal frame of the observer, which is the more tolerable when we remember that mass in any case is only a mathematical coefficient put in to make the laws of motion "work." Incidentally it

is only on these grounds that we are led to believe that mass and energy are different aspects of the same underlying quantity. For electric charges and light they may be proved to be so. Since ordinary "matter" seems to be "nothing but" electric charges, it seems likely to be true also for it. Thus what at first appeared to be an anomaly in the electrical theory of matter turns out to be a theoretical necessity according to the results derived from considerations wholly independent of that theory. Later work by Aston actually showed that the deviation from the "whole number rule" (*vide* p. 313 *supra*) was an almost universal property of atoms, the discrepancy in every case being greater than the exceedingly delicate method could admit of through chance error.

We now turn to the one natural "force," which, although completely described in mathematical terms by Newton, appeared to act miraculously, that is, without any "cause" such as could be correlated with known causes. With the development of the physics of the electromagnetic field it became customary to assume a gravitational "field" instead of an instantaneous action at a distance; but the "cause" of the field remained as mysterious as ever. In the solution of this problem Einstein directs attention to two facts of prime importance, namely, the identity of gravitational and inertial mass independent of the nature of the gravitating bodies, and the relativity of force to an observer on a uniformly accelerated frame. The recognition of the former permits the assumption of the latter; for an observer on a uniformly accelerated frame can thus have no evidence capable of refuting his firm belief that he is fixed in a gravi-

tational field and unsupported bodies are being accelerated thereby. But it has a second no less important result, namely, that it affords the strongest evidence for the view that the cause of gravitation must lie not in the separated bodies but in the field containing them. This of course is merely shifting the problem; the solution finally obtained was of a kind quite unfamiliar to physics; indeed, it at first appears hardly to come within the realm of science at all, but further enquiry dispels this view and shows us that we must rather refine our conceptions of what a scientific theory ought to be.

For the simplest gravitational fields the explanation is to be sought *merely* in the relativity of accelerations; but this is uncommon; the general solution was arrived at only by the recognition (due mainly to Minkowski) that the physical "world" is a four-dimensional continuum, three of whose dimensions give us "space-like" information, and the fourth "time-like." A physical object is no stationary mass, but is determined by the tracks of its constituent particles in the continuum. Now owing to the fact that a ray of light would appear curved when observed from an accelerated body, and the further fact that it is impossible to distinguish the effects of an "external" gravitational field from those observed in empty space from an accelerated reference frame, we must conclude that a ray of light is curved when passing through a gravitational field. From this it follows that gravitational fields are to be interpreted as irregularities in the curvature of the spatio-temporal continuum. The exact enunciation of the law of gravitation, which was made possible by the combination of Gauss's analytical geometry of curved surfaces with Minkowski's

four-dimensional geometry, fortunately does not concern us, except in the way that it not only "explains" gravitation, but shows it to be a special case of a more comprehensive law, according to which certain small effects (*e.g.* rotation of Mercury's perihelion), which the Newtonian law was unable to account for, are accurately determined.

The question of the nature of the spatio-temporal continuum is bound up with that as to whether the relativity theory is a "scientific" theory, that is, a theory of nature, at all. As soon as we begin to talk about reality being "nothing but" space-time, and all the "choir of heaven and furniture of the earth" being "nothing but" "kinks" in it, we are certainly not talking science; we are merely talking nonsense. Space and time are indeed found to be convenient abstractions; but you will not get reality by slamming them together any more than by adding skin and flesh to a skeleton you will get a frog. The term "space-time" is misleading; it should be replaced by some more concrete term, such a one as the "receptacle" used by Plato in the *Timaeus* (*vide* Whitehead, *Adventures of Ideas*, p. 192). In the same way, although it is perfectly clear what we mean by a "kink" or "warp" in a surface, it is not only impossible to picture such a thing in space-time, it is thoroughly misleading. I do not propose to enter at length into this matter, which I shall touch upon again at a later stage; it must suffice to say that so far as I can apprehend it, relativity forms a new code of rules for spatio-temporal relationships which supersede, by including, the old Galileo–Newton code. Nature fills space and time; so that if we use the wrong rules for exploring space and time we shall enunciate the

wrong, or at best the incomplete, laws of nature. On the other hand, it must be borne in mind that these rules are in the form of highly abstract mathematical statements, relations between numbers, and the ascribing to them of physical properties, derived from the earlier "materialistic" phase in physics, merely leads to confusion. The law of gravitation is a law of nature in so far as it tells us that the cosmic continuum behaves as if it were structured, and indicates the sort of structure possessed by various regions characterized by recognizable and classified events. The Gaussian co-ordinates in which these singularities of structure are specified are not "scientific" any more than the Cartesian coefficients of the Galilean reference frame were "scientific": an interval is no more "real" than a "length," it is merely more precisely determinable, and as such capable of being the basis of wider generalizations. Already its substitution for action has made the principle of least action applicable to all gravitational phenomena; in his "unitary field theory" Einstein has tried to apply it to the case of electrons and light rays, but success is not yet established.

I cannot close this discussion without reference to the question as to whether by maintaining the distinction between physics and geometry we can interpret the facts without recourse to the assumption of non-Euclidean space. I can, of course, form no opinion whatever on the validity of this theory; but I agree with Sir Arthur Eddington (*The Nature of the Physical World*, pp. 145, 146) that we cannot regard the matter as of no consequence, as does Lord Russell (*The Analysis of Matter*, p. 75 *et seq.*). From the broadly philosophical point of view I should be inclined to

follow Professor Whitehead in his belief that it is actually more *true* to describe the spatio-temporal continuum in terms of spatial concepts that we can visualize, rather than in what appear to be arbitrary analytical coefficients. But an inclination is all I can claim.

We have now to consider that development of modern physics which, at first in radical opposition to classical views, and at least having no point of contact with relativity, has in the last few years converted the science of physics into a storm-centre such as has hardly ever been witnessed before in the history of science.

For the interpretation of three independent phenomena (*viz.* the distribution of energy in a "full" radiator, the specific heat at low temperatures, and the so-called photoelectric effect) it was found necessary to repudiate the classical principle of equipartition of energy. In the case of the photoelectric effect, for instance, the velocity of the released electrons depends, for a given metal, only on the frequency of the incident radiation; it is independent of the intensity of the radiation which serves only to regulate the number released. In other words, since an increase of intensity means an increase of available kinetic energy, and since, on the other hand, the actual kinetic energy of the individual molecule is constant and independent of this, it follows that energy can be transferred only in discrete units, as is the case with matter during chemical action. The energy is conserved, but its distribution depends upon a factor other than itself. This factor, discovered by Planck for a "full" radiator, and introduced by Einstein into the interpretation of the photoelectric effect, is that the energy absorbed is

proportional to the frequency, the proportionality constant being a natural quantity of universal significance. This minimum amount of energy which is transferable is known as the quantum, and of course varies with the frequency of the radiation. Thus the "atom" of energy differs from the atoms of matter in that its magnitude varies continuously (in so far as we have no positive knowledge of any lack of continuity in the range of frequencies). Consequently, as Lord Russell says (*Analysis of Matter*, p. 37), while energy is conserved, it is really "action" (*i.e.* the product of energy and time) that is quantized; if constancy is to be the test of permanence, then action must be regarded as more fundamental than energy.

These highly revolutionary views might have made little headway had it not been for the fact that Niels Bohr was able, on their assumption, to explain in detail both the normal and fine-structure spectra of hydrogen, a regularity in the frequency of which had been discovered by Balmer, Ritz, and Rydberg. The orbits of the electrons postulated by Rutherford could be calculated in terms of the frequency of their radiation, it being assumed that the atom radiated only when an electron "jumped" from an orbit characterized by a particular quantum number to one nearer the centre with a smaller quantum number. Unfortunately this hypothesis seemed to have proved much more than in fact it had. So long as it was concerned with the correlation of radiation frequency with the energy states of electrons, its results were surprisingly accurate, and its presuppositions unexceptionable. But in proceeding to construct atomic models composed of a nuleus surrounded by numerically defined

electronic *orbits*, it had passed into a world of things-in-themselves for the interpretation of which, since its evidence about electrons was wholly limited to their "jumps," it had no knowledge.

During the heyday of the Bohr hypothesis the radical opposition between the classical and quantum theories of energy seemed to be hardening. The classical theory alone could explain interference and polarization, that is, the vectorial qualities of radiation, which the quantum theory fails to indicate. On the other hand, the classical theory involved the very equipartition which the quantum theory, in order to account for the phenomena referred to above, flatly denied. Finally, the theory of relativity, while straightening out certain tangles in the classical theory, with which it is in no way directly opposed, was unable to account for the existence of quanta.

The resolution of this contradiction is not yet quite complete. The formal opposition may be removed by supposing that the equipartition principle demanded by the classical theory is in accord with the quantum theory for all those cases where large quantum numbers are involved; but this in no way explains the qualitative facts of interference, etc. A more promising method has been the application of a kind of relativity principle to the interior of the atom. *The justification of this line of attack seems to be in the fact that we have no knowledge of electrons at rest.* This being the case, can we with any justice speak about the definite "position" of an electron with respect to any ordinary frame of reference? Experimental results themselves appear to confirm this point of view. According to Heisenberg we

may determine, without theoretical limit of accuracy, either the position or the velocity of an electron, but not both. This has been described as the Uncertainty relation by some, and as the Principle of Indeterminacy by Eddington. The views of the last-named have given rise to much discussion, and not a little adverse criticism. With his usual fertility of illustration Sir Arthur Eddington indicates how it is impossible to locate an electron either by high frequency radiation, whose large quanta would violently disturb it, or by that of low frequency, whose small quanta are associated with wave-lengths comparable with the size of the electron (whatever that may mean), and therefore giving but blurred diffraction images. This, according to him, is no casual dilemma due to ignorance, but "a cunningly devised plot to prevent you from seeing something that does not exist, *viz.* the locality of the electron . . ." (*The Nature of the Physical World*, p. 220). Professor G. P. Thomson, on the other hand, suggests that "if anybody were to discover any probe more delicate than an electron, the argument would break down" (*op. cit.*, p. 224). Although the universally valid reciprocal relationship between quantum magnitude and wave frequency is certainly significant in this connection, it seems to me that Professor Thomson does well to point out that the argument is necessarily based to some extent on negative evidence. As I have indicated above, it is quite possible that the whole matter is merely a trial of words: until it has been clearly proved that location is an essential part of the definition of the conceptual entity which is called an electron, it is quite useless to argue whether it can be precisely determined. Or to turn the discussion

inside out, perhaps it would tend to clarity if it were urged that, since the assumption of an exact position at an instant of a moving electron leads to absurd conclusions, it may reasonably be doubted whether the electron has any of the geometrical characteristics of a vanishingly small particle after all (*cf.* Bavink on the "temperature of molecules," *op. cit.*, p. 219). If this is what Sir Arthur Eddington means, he obscures the point by saying with reference to Schrödinger's (*vide infra*, p. 340) theory that it "refrains from attributing to a *particle* a kind of determinacy which does not correspond to anything in nature" (*op. cit.*, p. 225; italics my own). I confess that although the fact that an *electron* has no determinable position does no violence to my sense of the fitness of things, I find an indeterminable *particle* simply inconceivable (*cf.* N. Campbell, "The Errors of Sir Arthur Eddington," *Philosophy*, No. 22, p. 180).

When Sir Arthur Eddington proceeded further to deduce from the fact of indeterminacy the view that "physics is no longer pledged to a scheme of deterministic law" (*op. cit.*, p. 294), and that "science thereby withdraws its moral opposition to free-will" (*op. cit.*, p. 295), he started the controversy which is spreading outwards through all parts of the thinking world. This question is bound up with another which merits our close if somewhat mystified attention, namely, the attempt to reconcile the atomic and periodic-continuum views of matter and energy.

This reconciliation was prompted by two specific problems, which may be roughly enunciated as follows: If, as the special theory of relativity seems to show, there is no ether, how does light from a distant star reach us?

If we reply "As a periodic disturbance," there still remains the problem "Of what?" If, with Newton, we incline to the belief in a stream of light-producing particles, how are we to account for interference, which, as Newton himself recognized, involves *some* periodic disturbance? The second problem is the older one, of how a particle of matter is determined to follow a path such that the principle of least action holds. The answers to these queries came in the experiments of G. P. Thomson and others, who showed that a stream of electrons, which normally shows no periodic phenomena, nevertheless produces a diffraction pattern when shot through a sufficiently thin metallic film, and in the mathematical theories of De Broglie and Schrödinger, which are roughly to the effect that an electron is at the same time a point charge and a train of waves. If this solution seems to be having the best of both worlds, it should be borne in mind that there is no question of the point charge "causing" a train of waves to move out from it; on the contrary it is the distribution of the waves that determines the apparently discrete charge. The electron is, so to speak, everywhere at once, but the density of its waves is a measure of the probability of its action in that region. (Space is lacking for a fuller treatment of these interesting questions; I can but refer the reader to the beautifully clear account given by Sir James Jeans in *The New Background of Science*, especially Chap. VI).

This theory seems at first to have unified in one conception the apparent contradictions between the classical, relativity, quantum, and indeterminacy theories; and to a very large extent this is true. But unfortunately it has

achieved this only by introducing conditions which, as I see it, seem to destroy the very foundations upon which it rests. First of these is the denial of the validity of the principle of strict causation; the second is the admitted use of symbols without any physical meaning.

With regard to the former it is surely pertinent to enquire whether a train of reasoning which has been built up by the progressive application of the concept of causation is at liberty to include among its results the denial of the validity of this concept? Is it not rather a question of the right and the wrong way of applying the concept? Or, in other words, is it once again a case of a concept, framed to meet the needs of a limited mass of knowledge, having to be enlarged before it can embrace fields of thought undreamed of by its founders? (*cf.* the remarks of Professor Einstein quoted by Jeans in *The New Background of Science*, pp. 228, 229; also Professor Planck's discussion in his book *Where Is Science Going?* Chap. II). In any case, we should do well to bear in mind the opinion of the founder of the theory that has caused most of the trouble, namely, that "the *experimental* skill of physicists, which in the past has so often definitely decided questions full of doubt and difficulty, will succeed in resolving the difficulties of the present obscure question" (Max Planck, *The Universe in the Light of Modern Physics*; p. 106; italics my own). Perhaps this view is bound up with the second condition above alluded to, namely, the expression of the theory in terms of symbols having no physical meaning, but as I wish to treat of that in another connection (*vide infra*, p. 382) I shall not comment on it here.

*

CHAPTER XXII

LIFE AND MIND

"FOR methinks no golden chain let down to earth from heaven above the races of mortal beings, nor did the sea and waves which lash the rocks produce them, but the same earth bare them which now feeds them from herself" (*On the Nature of Things*, Munro's trans., p. 72). In these words Lucretius admits that for a self-consistent materialism some sort of spontaneous generation is essential; no fiat of a transcendent deity, no wafting of seeds from extra-mundane sources, can be assumed without making of philosophy a farce. Life is all around us, within us, and must be accounted for.

Now it is the aim of any monistic philosophy of nature to exhibit the living and the non-living, either as derivable the one from the other, or as "aspects" of some more "perfect" (in the Spinozistic sense) unity. The solution of the problem may be sought in three ways. In the first place the phenomena of life may be reduced to the status of "nothing but" the manifestation of a so far inexplicably complex interplay of portions of matter; this, in its simplest form, is the naïve materialism of the French Illumination; in a more refined form, its harshness softened by the blessed word "evolution," it was the basis of Haeckel's monism. The opposite point of view is that matter is, as it were, the residue of life; life is prior to matter, which it makes use of to manifest itself. Thus baldly put, the antithesis to

materialism has had few protagonists; but primitive hylozoism no less than an influential modern school of biologists, of which Professor J. S. Haldane may be taken as a representative, both stress the primacy of the attributes of life, the following dictum of Professor Haldane being worth quoting: "That a meeting-point between biology and physical science may at some time be found, there is no reason for doubting. But we may confidently predict that when the meeting-point is found, and one of the sciences is swallowed up, that one will not be biology" (quoted by Professor J. S. Haldane from an earlier address in *The Philosophical Basis of Biology*, 1931, p. 33). The middle path, which is the easiest, if at the same time the most sterile, is the "double aspect" theory, which regards matter and life as co-relative aspects of an underlying reality. Here, again, it is only when linked with some enlivening concept such as "emergence" that this view has been considered worth espousing; which is not surprising, for any form of parallelism must really shirk the issue unless it can show *why* a single substance *can* and *does* manifest itself under two aspects. As I have said before in another connection (*vide supra*, p. 84), it may be that the final solution will be of such a kind; but if so it will be less a "solution" than a recognition of the ultimate limit of knowledge.

The above classification of the possible approaches to our problem is by no means exhaustive, for although logically there can be no other manner of determining the relation between two classes, logic breaks down here, as so often, in face of the fact that the classes themselves have changed during the history of the struggle to relate them. Thus

whereas General Smuts unambiguously asserts his belief in the origin of life from matter, saying, "We accept the theory of descent, of life from matter, and of the mind from both" (*Holism and Evolution*, 2nd edn., p. 9), his theory cannot with propriety be regarded as belonging to the type of materialism, since his use of the term matter clearly indicates that this stuff has undergone considerable "vitalizing" and "organizing" since the days of Robinet and Holbach, or even those of Haeckel. I shall therefore make no attempt to keep rigidly to this threefold classification, though its recognition may help us to keep the issue before us clearly defined.

Before reviewing the possible solutions of this problem which display a monistic character, it is necessary to point out that throughout the history of biological science the dualistic view that matter and life belong to two categorically distinct orders of existence has had a more vigorous career than many would care to admit, and is still a force to be reckoned with. This view, which is conveniently, though if it be thereby suggested that there is only one such view, erroneously, described as "vitalism," has been brilliantly championed in recent years by Professor Driesch. Now though I accept the usual reasons for rejecting Professor Driesch's ultimate conclusions, I feel so strongly that the more recondite aspects of biological philosophy, no less than the teaching of the elements of biology, are being needlessly impoverished of true biological content that I shall open this discussion by a brief summary of what I believe Professor Driesch has established in the realm of theoretical biology. Nor can this be regarded as a digression; for a monism which appears to succeed by virtue of ignoring all

the difficulties is what above all we should seek to eschew. In this thesis I seek no solution, but assess tendencies.

Before attempting a short analysis of Professor Driesch's views I had better make it quite clear that I intend to make no use of them to dispose of the first type of theories above alluded to; I mean that in which life is held to be "nothing but" the manifestation of physico-chemical processes of a high order of complexity. Let me say at once that I can see no use in discussing such a possibility. As an amateur with a taste for philosophy I am compelled to consign this to the limbo of what Dr. Broad calls "silly theories"; that is, the sort of theories which may be tolerated for a time as a methodological shift, but by which no one, not even their stoutest protagonists, would dream of shaping his life. In short, it is the sort of theory that has driven the cultured man, who likes an occasional exercise in clear thinking, to detective fiction. I give only one reason for this opinion, namely, that to anyone who does not spend his days in scientific blinkers the attempt to derive the infinite beauty and subtlety, the varied and ever-changing interplay, the wholesale extravagance combined with a marvellous fitness, of the world of living creatures from the behaviour of matter as determined by laws of a purely physico-chemical character is not only futile in itself, but in that it has had, and is having, a cramping, distorting influence on the young science of biology with the world at its feet, it is *pseudo*-scientific lumber, whose inertia may do permanent damage to mankind. There should be a special philosophical cleansing department, charged with the task of removing and destroying such stuff.

I shall, of course, be told that it is the acceptance of this creed which has rendered possible the magnificent progress of physiology in recent years. My reply is twofold: in the first place I believe that much of this work has been done either without reference to mechanism or even in its tacit rejection (*cf.* Sir F. Gowland Hopkins, "I often find myself compelled to assert that though biochemical events are, of course, limited by chemical possibilities, they are not safely to be predicted by chemical probabilities, even when these are strong"—*Roy. Soc. Anniv. Address*, 1932); and, secondly, while admitting the brilliant results achieved within the limits set by the abstract nature of the postulates, I shall point to the increasing mortality from cancer, and our sublime ignorance of the causation and treatment of such old friends as rheumatism and the common cold. I humbly suggest that this continued ignorance is due to the obsolescence of the empirical method; we no longer frame hypotheses on the basis of carefully thought out experiments on animals and plants, but at once attempt explanations purely in terms of abstractions of such refinement as hydrogen ion concentration. Too often the skill and ingenuity of the investigator are absorbed in paring and squeezing the biological data into a hypothetical physico-chemical mould. Here I anticipate my discussion of Professor Driesch's work when I allude to his remarks on the correlation of protoplasm and foam structure: naturally, he says, if the substance conjoined with the phenomena of life happens to be a liquid disperse system, it will obey the laws common to this system; but to infer from this that life itself is "nothing but" a surpassingly complex and delicately

equilibrated disperse system is to fall into the error we have already so often deplored. Even if, which to me is unthinkable, life is no more than this, the judgment from such evidence must be hopeful ignorance: we have found nothing else—perhaps there is nothing else. But before we proceed to use the result as a basis of philosophy we must show that the mechanistic conception is sufficient to account for the phenomena of life, which it certainly is not unless we exclude just those very features, tropisms, regeneration, sexual selection, metabolism, and the like which occur for the benefit of the organism or the race, and whose meaning cannot, even if their mechanism can, be explained by physico-chemical concepts. As Dr. Bavink—a physicist—says: "If there are purposive connections in nature, they are just as much a part of nature as causal connections. Anyone wishing to understand nature must pay attention to both, otherwise he will become one-sided, and place obstacles in his own path towards the true understanding of nature" (*op. cit.*, p. 399).

I have thought it best to emphasize my rejection of the mechanistic basis of life on general categorial grounds, in case my admiration of so much of Professor Driesch's thought should be misconstrued as a leaning towards vitalism. We may now turn to a more detailed consideration of such of his views as may help us to some sort of solution of our present problem.

In a review as condensed as this will have to be, it may be pardonable to give Professor Driesch's general attitude before embarking on an account of his special contributions; particularly must we clearly bear in mind what he does *not*

believe. That this should be necessary is regrettable, but seems unavoidable seeing that he is often referred to as if his teaching were analogous to the crude conceptions of sensational fiction, in which a "life force" is "injected" into inert matter by means of an array of transformers, discharge tubes, and alembics, such as Mr. Heath Robinson might glory in. Two excerpts will be sufficient, both from his book *The History and Theory of Vitalism*, which appeared in an English translation in 1914. The first is his quotation of Stahl's summary of his vitalistic system: "It cannot be too often repeated that the basis of life consists of activity, not matter; and of activity not in matter but operating on it in such a manner that the matter remains purely passive and indifferent, and merely obeys the activity which distributes and orders it in a given structure." Professor Driesch rejects this naïve dualistic vitalism in the words: "Had such a theory really any claim to exercise an influence over so many decades? Can we detect any advance, however small, on the biological views of Aristotle—and must we not rather admit an actual retrogression?" (*op. cit.*, pp. 34, 35). With approval, however, he quotes Wolff's dictum that "We must carefully distinguish the growing substance from the machine which envelops it. But the machine must be regarded as its product" (*op. cit.*, p. 47). And no wonder. Indeed, if Wolff had avoided the to us superfluous conception of *vis essentialis* his views might have been regarded as the forerunners of the "organic" philosophy which has so large a following to-day; but it is doubtful whether, in that event, he would have been at all intelligible to his contemporaries.

It is clear, then, that Professor Driesch holds no brief for vitalism in the crude form in which opponents of the theory are apt to represent it. He arrives at his own form of vitalism mainly as the outcome of the following considerations, which, as will be seen, are partly empirical, partly analytical. The most important basis of his reasoning is, of course, the observed fact of morphogenesis by segmentation and subsequent differentiation of a single internally complex but externally simple spherical unit. Now if this always occurred according to an irrevocable plan and sequence for a particular species it would be as difficult to deny as to affirm that it was nothing more than the creation by a machine of new structures from the raw materials of its environment; but from the observed formation of a complete larva from *one* of the first two blastomeres (the other being killed) it appears that the supposed products of these machines are themselves machines capable of performing precisely the same tasks as those which created them. In my view, this destroys at once all validity of the argument that organisms are *machines* of a high degree of complexity; for we know of no *machine* which can perform an operation of this kind, however simple the product might be. But it does not wholly dispose of the possibility that the egg is a highly complex physico-chemical system, the disturbance of whose predetermined conditions by the removal of one of its products (the killed blastomere) might not cause its other product to repeat the first kind of change. I admit that it places a strain on one's faith in the potentiality of such a system, but all I am urging is that it does not seem to me *a priori* impossible.

The next class of phenomena, however, to which Professor Driesch draws our attention are such that to explain them the mechanist is driven to make assertions which, in my view, reveal the essential "silliness" of his theory. These are the regeneration phenomena in coelenterates and ascidians. Of the two examples, which appear to me to carry most weight in this connection, the first is the fact that though the "head" of the hydroid Tubularia may be regenerated from any part of the stem, yet the size of the regenerated organ is roughly proportional to the size of the stem cut. In other words, not only does every "machine" in the organism exert an influence on the course of the new process, but they all "know" that the bigger the body that is to be fed the bigger must the head be. "Silly" as such an explanation sounds, it is pure common sense compared with that which must be applied to the second case. This is the behaviour of the ascidian Clavellina, whose branchial apparatus being isolated and bisected loses all its typical organization, becomes spherical, and re-emerges a complete, reduced Clavellina. No one, I suppose, would now be so mechanistically inclined as to argue that to a system, which is such that one of its parts may revert to an undifferentiated mass in order to reconstitute the whole, the term "machine" can be applied in any sense ever recognized in current speech; rather would it be urged that the artificial disturbance of the conditions of change in a highly complex physico-chemical system might cause a reversal of the direction of that change until such a past configuration had once more been reached, whence progress might recommence on the old lines. Now the strongest

argument in favour of mechanism is that it explains biological phenomena wholly in terms of *verae causae*, yet, so far as I am aware, no one has ever observed a system of such a kind as the above, apart, that is, from association with a living organism; it is therefore no *vera causa*.

We have seen enough of the evidence to admit that physico-chemical theories, though unquestionably true and necessary to account for the phenomena of life, are as certainly not sufficient. We must therefore turn to the much more difficult problem of determining what is.

Professor Driesch's solution, as is well known, is that this "harmonious equipotentiality," this "all-in-allness" of the living organism is rendered possible by the existence of an autonomous factor called the "entelechy." Much of what Professor Driesch has to say about entelechy is illuminating in the highest degree, serving to clear the ground still further for any alternative solution, but at the end one is left wondering whether, like Kant in his study of the problems of knowledge, the author would not have performed a greater service to science and philosophy if he had been content with stating the prolegomena to every future study of life instead of foisting on the organism a ghostly order of negations which explain nothing and may easily reintroduce just those confused thoughts which he has been at such pains to lay bare. The indictment against entelechy must now be justified, and in the process we shall learn much more that will be of use to us later in attempting to reach a more positive conclusion.

It hardly needs to be affirmed that entelechy consists neither of "matter" nor of "spirit"; nor can it in any way

cause a violation of the laws of chemistry and physics. It is interesting to note in this connection that Professor Driesch urges the same view as we have been unable to avoid, namely, that the so-called "laws" of energetics are aprioristic and therefore necessarily "obeyed" by entelechy as by anything else. ("Energy is causality quantitatively determined"—*Science and Philosophy of the Organism*, Vol. II, pp. 162–4. In the next chapter I indicate my preference for the term "plausible" instead of "aprioristic," *vide infra*, p. 381.) Since "*entelechy lacks all the characteristics of quantity*: . . . *is order* of relation and absolutely *nothing* else" (*op. cit.*, p. 169), it is definitely wrong to speak of "vital energy" as it is to speak of "living matter." Further, entelechy is neither extended nor in space, though it acts into space. I pass over the enumeration of all the qualities that entelechy does not possess; what, then, is it? Unfortunately to this question its proud creator in effect replies, "Ah, now you're asking!" In fact he admits that "for the present" entelechy must be defined only as a set of negations. One positive quality it seems to have, namely, the power of suspending physico-chemical action, and then in due season setting free those potentials it has itself created. How it does this we are not told; and of the fact that it does do so we are given no sort of proof. It is therefore no *vera causa*, but a mere name for the "something" which with perfect cogency Professor Driesch has shown distinguishes the "vital" from the "physical." It has therefore been of no use as a guide to further investigation; and has done incalculable harm by playing into the hands of sensation-mongers, and thus, by confusing the real, demonstrated

differences between the two realms of nature, given to the theory of mechanism a further lease of life quite unjustified by its shallow foundations.

Rejecting both mechanism and vitalism we are in the unenviable position of having at least to indicate the sort of solution of this agelong problem which the generally accepted doctrines of biology seem to point to, and then to assess to what extent it fits in with a monistic interpretation of nature.

Let us once again clarify the issue. The world presents itself to us as an assemblage of bodies which at present may be sharply divided into living and non-living. But whereas it is a comparatively simple matter to decide to which class any particular body belongs, yet the two classes have so much in common that it has been urged that the one is merely a special development of the other. These common factors are, that in the class of bodies having the character of life no matter is ever found which either has not been, or we have adequate reason to believe will not ultimately be, made out of the materials existing in non-living bodies, and by the operation of forces (such as radiation), and according to the same laws (*e.g.* those of chemical mass action), as operate in the non-living class. Further, the individual members of the living class appear to be capable of arrangement in a strikingly regular series, in which each grade is related to those below it only in regard to the greater complexity and variety of its functions, but without any abrupt change in the materials or laws of their behaviour. All this has been set out at greater length in Chapters XIII and XIV. We may therefore conclude that the world of the living is

one in substance and causal relation; that the worlds of the living and the non-living are one in substance; and that the laws of the latter are sufficient to account for all the abstract functions of the former to which they are relevant. But that they are in any way adequate to explain the living world as "nothing but" complexes of the non-living as apprehended under those categories of physics and chemistry by which they in their turn have been shown to be a unity has, with some show of passion, been hotly denied.

If this world of ours had not, with as much certainty as any non-observable inference can possess, once been a sphere of molten material at a temperature far above that at which any living body could exist, the origin of life would be a problem for biology no more than the origin of hydrogen is for chemistry. Moreover, the problem might in that case be solved by the simple expedient of assuming that since the category of life is a fuller, more complex one than those of matter and energy, then life is the primordial condition for the production of all else; and indeed this would be a *vera causa*, seeing that every organism, either during life or when spent through age, produces many kinds of matter and energy not having in themselves any of the marks of their living origin. But cosmical conditions having been what they were this will not do, at least not in the simple form thus stated. The only alternative is Lucretius' "golden chain." I can see no way of disproving the possibility of some cosmical "life reservoir" whose spores float about in space; but it is at best only an *asylum ignorantiae*. Nevertheless, I agree with Dr. Woodger that any attempt to

propound a theory of the *process* of abiogenesis is in the present state of our knowledge merely a waste of time and an encouragement to woolly thinking (*vide* J. M. Woodger, *Biological Principles*, pp. 405–8). We are driven back, then, ruthlessly to the quest for evidence of some sort of abiogenesis.

Now the generation of any organisms, clearly and distinctly recognized as such, except from pre-existing living organisms of the same character, has never been authenticated. At first sight, then, this path towards the reconciliation of the living and the non-living seems closed to us; for though the evidence is negative it is not merely negative, since nutrient media, which have remained sterile for years, although subject to all the external conditions favourable to multiplication, have, on the entry of a few suitable organisms, within a few days teemed with the latter's progeny.

At the close of the nineteenth century the problem appeared to be insoluble; but once again the investigation of a comparatively superficial problem, namely, the conditions of infection and transmission of diseases like fowl pox and tomato mosaic, bids fair to lead us far towards, not indeed the solution, but the restatement of the problem of life itself. As Professor Boycott has said, "The difficulty in most scientific work lies in framing the questions rather than in finding the answers" ("The Transition from the Living to the Dead," *Nature*, January 19, 1929, p. 95). The study of the viruses is at present surrounded with great technical difficulties, and any attempt at dogmatic assertion would be ill-timed; but there seems little doubt that their

properties are such as to make their classification as either "living" or "non-living" exceedingly difficult. Thus whereas they are certainly smaller than any known living organism, some appearing to be little larger than the molecule of a "chemical substance" such as haemoglobin, on the other hand they seem to have the power of multiplication, which of all its properties is the most typical of the living being. Nevertheless this property can be ascribed to the virus only with caution, since the evidence so far goes against the possibility of multiplication in the absence of living cells; hence the alternative hypothesis that the virus is a product of the organism suffering from deranged metabolism, although unlikely, cannot be definitely ruled out. Unless this hypothesis, by which living cells are believed when stimulated by small quantities of the virus to ensure their own destruction by the generation of more virus—a hypothesis, which, as Dr. Dale points out, would render incomprehensible the fact of exclusion of rabies from a country (H. H. Dale, "The Biological Nature of the Viruses," *Nature*, October 10, 1931, p. 601)—is substantiated, we seem at last to be at grips with the "missing link" between the living and the non-living; or, as we should prefer to say, we have been shown why the disputes as to the relation between the living and the non-living have been so fruitless, namely, that we have been striving to resolve an antithesis erected by the insufficiency of our own analysis but having no existence in nature. So long as an organism could, as we assumed on page 353, be easily distinguished from "dead matter," the antithesis was justifiable and the fact of biogenesis true; but now that we know that associated with

the higher organisms are on the one hand products like the enzymes, bacteriophage, chlorophyll, and haemoglobin, whose powers surpass those of any ordinary chemical compounds, and, on the other, bodies like the viruses whose characteristics fall short of any organism that we can clearly and distinctly recognize as such, is it going too far to suggest that there exist in nature all gradations of material complexes from the electron (supposing this to have, as it does, some of the properties of "matter," and since its "simple location" is mythical it must in some sense be complex —*vide infra*, Chapter XXIII) to man, and at no stage does electric "energy" sharply change into "matter," nor "matter" change into "life"? If objection be taken to the erection of so ambitious a fabric on the basis of the supposed facts of agricultural pests, let it be emphasized that it is only because they *are* pests, that is, induce pathological symptoms, that the virus bodies have been discovered. It is no wild speculation to suppose that in the active material complex which weaves the web of life there are many other such bodies whose function is the creation and sustaining of life, but which by reason of their unobtrusive harmony must at present blush unseen.

If the more probable hypothesis concerning the nature of the viruses be ultimately confirmed, we shall have then a more or less complete "evolutionary" chain from the electron and proton to man, and the true nature of the present sharp dualism between matter and life will be revealed, namely, as the internal dualism between two contradictory concepts. Yet this result, important though it would be, cannot entirely satisfy us. Before we can feel convinced of the possibility of

the monistic interpretation of the whole of nature, we must determine what, if any, principle of causation there exists which can relate such apparently diverse existents as a live frog and the clay it is sitting on.

The solution of this aspect of our problem can most usefully be attacked from opposite ends; whereby we shall, I think, find that the two roads meet, even if as yet we cannot see *how* they do.

In the first place we shall revert to the passage in the work of Professor Driesch already considered (*vide supra*, p. 349 *et seq.*). The observed facts of controlled segmentation and regeneration were used by him, rightly, as I think, to dispose once and for all of the crudely mechanistic theories of life; but here, I think, he lost a great opportunity of replacing them not by the shadowy entelechy, which has been a stumbling-block to many who would otherwise have been his followers, but by bearing in mind the words of Kant that "An organized product of nature is one in which every part is reciprocally purpose and means" (*Critique of Teleological Judgment*, English trans. by J. H. Barnard, London, 1892, p. 280). It is true that Kant drew the conclusion that the notion of purpose is valid only for us and not for the organism, but it is equally true that Professor Driesch recognized the unsatisfactory, if not actually confused, nature of this conclusion (*History and Theory of Vitalism*, p. 73 *et seq.*). The passage in Professor Driesch's major work which might have furnished us with the sort of solution I have in mind reads as follows: "Every volume which may perform morphogenesis completely must possess the machine in its totality. As now every element of one

volume may play any possible elemental rôle in every other it follows that each part of the whole harmonious system possesses any possible elemental part of the machine equally well, all parts of the system at the same time being constituents of different machines" (*Science and Philosophy of the Organism*, I, 140). This argument certainly lays bare the folly of the "nothing-but-machines" theory; equally certainly it provides no evidence for the existence of a super-organism, the entelechy. What it *does* show, however, is just what it says, namely, that there *is* mechanism, that is, material complexes in the reciprocal relation of means and end; but that there is also more than this, namely, that the mechanism is, as it were, pervasive, each "machine" by virtue of the intimacy subsisting between itself and its environment—an intimacy unparalleled in any artefact machine—is in touch with the whole.

Apart from the objection that this is no more than an alternative way of saying what Professor Driesch has already said more clearly, two new difficulties arise. First, how can "dead matter" put upon itself the activity of a machine? And secondly, have we any right to speak of a whole distinct from its parts? The appositeness of these two questions is indicated by the fact that they are not independent of one another, nor of that second approach to our problem (which I have already alluded to above), from the standpoint of matter. I shall deal with the second difficulty first, as we can more profitably tackle the first from the side of matter.

It is the stubborn refusal to acknowledge openly and at all times the existence of the organism or whole as more than (though naturally not distinct from) the sum of its

parts that in my view renders so much of the technically brilliant work in "General Physiology" misleading and harmful (*cf.* A. V. Hill, "Biology in Education and Human Life," *Nature*, January 3, 1931, p. 19 *et seq.*, especially p. 26). Of what conceivable use is thyroxin to the machine that makes it—the thyroid gland? Why, if the function of the branchial apparatus is gaseous flow, is it often fitted with backwardly directed ciliated epithelium? No answer, which does not recognize a certain element of purposiveness, of subordination of individual propensities to the good of the whole, can be more than a part of the answer, and a very small part at that.

We have not finished with this relationship of part to whole, but before turning the argument to our own advantage we shall proceed to the consideration of the first difficulty mentioned above.

That "dead matter" cannot merely by association with other different kinds of "dead matter" become endowed with the activity of life or even of simpler mechanism I shall freely grant. But before falling back upon the simple though repellent hypothesis of "vital force," let us remind ourselves of the fact that the "dead matter" of ancient materialism *is* so in every sense of the term; in fact, it never existed except as the product of confused thinking. The matter of modern physics is, we have seen, something far remote from a cloud of infinitesimal billiard balls. It is, so far as the physicists allow it to be anything at all, one of the manifestations of centres of action, these centres, or may be only their directed action, being in constant motion. Here, again, we find one of Professor Driesch's difficulties

met, namely, that the "machines" of the living organism would have to "overlap"; but that is precisely what we are being led to believe does happen with the elementary basis of matter. There is no such thing as an electron at a point; there is a field, at any point within which there is a determinable probability that the electron may at any given instant be "found"; matter, on the ultra-ultramicroscopic scale, is also pervasive. (This argument is amplified in Chapter XXIII *infra*.)

The last problem is the greatest of all, and as such includes all that have gone before. The common man, had he the patience to read the above arguments, would, even if he were to admit their appositeness, almost certainly state his final unconviction in some such terms as these: "Yes, but how can certain chemical elements when placed in a peculiar relationship begin to manifest those activities which characterize the simplest living things? The fact that you have indicated the possibility of a complete series in which this constellation of properties gradually emerges is no explanation of *why* it emerges." The reply to this awkward question would be in the form for which there are great precedents, namely, of another question: "For a century or more men of all sorts and conditions have been quite content to accept two facts as being on the same plane of inexplicability, namely, that copper sulphate is blue and not pink, and that when a soft, silvery metal is mixed with a green, corrosive, poisonous gas, a colourless, harmless, crystalline, solid results. Now these two facts belong to entirely different orders. The blueness of copper sulphate is merely one of those many sense qualities which taken together constitute that which

for brevity we call "copper sulphate," "blue vitriol," etc.; if the blueness were not compresent with the other qualities under normal conditions we should know that the name "copper sulphate" was no longer applicable. There is nothing to "explain"; the blueness is, as we say, part of the "givenness." But the appearance of common salt after the approximation of chlorine to sodium is not part of the original "givenness" at all; yet it is accepted as a fact which needs no explanation. If you accept this, why are you unwilling to accept the possibility—for that is what is at stake—that given a certain association of complex compounds related in a peculiar way to their environment, the appearance of that constellation of properties characteristic of the simplest organism (not of life, which is merely a universal abstracted from actual organisms), accept it, that is, without a demand that this novelty should be "explained"? It is a natural enough demand, but if raised in this case why not in the former? (Professor Alexander suggests that "chemism" may have to be accepted as an intermediate emergent level between matter and life—*Space, Time, and Deity*, Bk. III, Chap. II.)

I shall suppose that the unfortunate "common man" has as usual been silenced by the experts, and while he is searching for the weak spot in the argument I shall be charitable enough to point it out to him, and also to try and convince him that the apparent weakness of the particular argument indicates how the general position is to be held.

As I see it, the only fault in the analogy is that, though it is very nearly true to say that no explanation has ever been required of the production of totally new substances from

the union of others, it is not entirely true; for it was largely by the recognition that no such explanation is possible that the black art of alchemy became the more or less exact science of chemistry. (Boyle in a passage already quoted emphasizes that the new properties "belong to the concrete itself"—*vide supra*, p. 176.) So long as man sought the "principles" and "causes" of the change of one kind of matter into another, progress in knowledge was slow and uncertain; when their aim was the precise determination of the conditions—material and otherwise—of such changes, progress leapt forward with swift and certain stride. But despite this dazzling accumulation of knowledge, despite also the revealing of the inward secrets of the atom, we are and for ever must remain ignorant as to why the compound of hydrogen and oxygen is a neutral liquid and that of hydrogen and chlorine is a poisonous gas. These, then, are to be regarded as facts no less than that of the blueness of copper sulphate; "emergent facts" if you desire a name to indicate that they belong to a different order, but part of the total giveness of nature.

The argument is then, I think, justified; but if we analyse these "emergent facts" of chemistry from a different point of view, we shall by analogy be able to strengthen even further the bonds between the "quick and the dead." Anyone who has tried, year after year, to explain to young minds that common salt is "made of" a silvery metal and a green gas must have noticed the blank apathy on the faces of weaker listeners, the candid scepticism on those of the brighter. And no wonder. For if he possesses any critical power, the teacher must soon recognize that he is trying to

teach metaphysics, and bad metaphysics at that. No one is going to be so easily fooled as to believe that common salt is "nothing but" sodium and chlorine, any more than he really believes that these elements are "nothing but" electric charges in motion. If this be accepted as true, but not as adequate, the statement that salt contains sodium and chlorine in the abstract sense that no measurable entity need be added to make it, nor can be extracted from it, by analogy we must accept, with the same reservations, the fact that living organisms "contain" nothing but matter and energy relations; that is, nothing else measurable can be extracted therefrom. But since physical science is concerned only with the measurable, it stands to reason that it must remain satisfied with this analysis.

In conclusion, we may profitably consider this question from the point of view made famous by General Smuts. Common salt is a whole; but if we wish to study its "make up" we must necessarily dissect it. Now there are various ways of dissecting it: we may analyse it into the elementary wholes of chemistry, and we shall get sodium and chlorine (also loss of energy); or we may cast the X-ray upon it and we shall *not* get sodium and chlorine, but spots on a photographic plate corresponding to a strictly orientated arrangement of atoms of sodium and chlorine; or by a slight variation in the use of the X-ray we shall get more spots, indicating that the atoms of sodium and chlorine are *not* atoms of sodium and chlorine at all, but constellations of electrons similar to those supposed to correspond to the elements but in which one electron has changed sides. Now none of these pictures tells us what the whole is; they provide us only

with abstract "views" of it. In the same way we may profitably analyse protoplasm (which incidentally is no longer a whole under the category of life, organisms alone being wholes) into water, proteins, salts, etc.; or into foam structure, etc.; or into irritability, etc. But once these various aspects are isolated from the field (*i.e.* set of pervasive relations) of the organism they cease to be wholes: they cease to be what they were *in* the organism, just as chlorine ceases to be what it was *in* common salt.

This lengthy discussion of the relations between the living and the non-living has, I hope, gone far enough to satisfy our original demands, which were to show that the unity of these apparently sharply demarcated realms *is* possible, to show *how* it is possible, and to present such evidence as there is to show that is actual. I have admittedly done no more than attempt to erect the skeleton of the bridge by which I think passage may be made between the two realms. Whole volumes could be, indeed have been, written to show how the skeleton may be compacted into a solid mass; thus I have done no more than allude, and that indirectly, to the ancient dilemmas of preformation and epigenesis, of inherited and acquired characters, and the like; but these problems can I believe be successfully tackled on the same general lines as those I have tried to sketch out for the main antinomy. It will be evident, though I have not tried to determine the individual sources of my stream of thought, that the chief of those springs have been Professors Alexander, Whitehead, Lossky, Lloyd Morgan, J. S. Haldane, and Dr. J. H. Woodger (see Bibliography at end).

I shall make no attempt to recapitulate the argument

here, since it is of the tissue of that which I shall ultimately put forward as the basis of a possible monism; I turn, therefore, to the consideration of mind.

No doubt it may seem strange to relegate the analysis of the crowning achievement of the universe, so far as the latter is known to us, to a mere corner of a discussion on life. There are reasons for this step. In the first place we are concerned with the monistic tendencies of science, and in my view, rightly or wrongly, it is not the business of science—indeed, it is not within its power—to analyse the working of mind. That a unity of life and mind *is* possible, *how* it is possible, and what evidence there may be that it is actual—these tasks alone I aim at undertaking. The fact of perception as being, perhaps, the outstanding character of mental activity must of course be incorporated in any such unitary scheme, but the study of the mechanism of perception rapidly passes beyond the limits which the abstract nature of scientific method imposes; passes, indeed, beyond even the philosophy of science. A complete monistic philosophy cannot shirk this problem in all its aspects, but the few remarks that I have to make on this will be in better perspective if placed in the final chapter. Here I shall keep within the limits I have mentioned above; and since I hope to show that it is merely by an extension of those principles we have elaborated in the critique of life that we may account for mind, it will soon be realized that our present problem need not occupy us very long.

When we consider exactly what sort of an entity it is which we have to try and show to be one with the rest of nature, we are met at the outset with difficulties such as

we have not had to contend with before. Let us first try to fix a provisional boundary between what a critical scientific study may hope to elucidate, and what, from the nature of its method, it cannot. To do this we may recall Haeckel's solution of the riddle—a solution, as he thought, of the whole range of mental phenomena—and see at what stage it definitely broke down. So long as he emphasized the gradual emergence of higher and higher levels of intelligent and ordered behaviour parallel with the development in the extent and complexity of the nervous system he was stating facts, which anyone may verify for himself. When he further put forward the view that it is this ramification of the means of control which makes possible the advance in intelligence, he was drawing a highly probable inference from a sufficient array of neurological evidence. Even the third stage in the argument, that in which he concluded that since there is no break either in the evolution of the nervous system or in the observable activity of the organism from the amoeba to man, therefore the two aspects of the phenomena are reciprocally related as cause and effect, and that no further principle of explanation, neither entelechy in the lower nor soul in the higher levels, is necessary, we may accept, with the reservation that by the principle of parsimony it appears entirely justifiable, but in no sense proved. Provided, therefore, we limit the discussion to the causal relations subsisting between observable phenomena, we accept Haeckel's solution as probably true if not quite complete; but the moment he insisted that the facts of consciousness can be explained as physico-chemical events in the ganglion cells he left science behind and for

the time being devoted his talents to the writing of fairy stories.

The ignoring of this distinction between what have been called "private" and "public" facts has led to such confusion that at the risk of being wearisome I must make the point perfectly clear before proceeding with my argument.

If an investigator presses a pin into the calf of a frog and that of a man some of the observable reactions will be the same in both cases; if he repeats the experiment after the sciatic plexus has been cut, in neither case will any reaction occur, and the man on being questioned would state that he "felt" a prick in the first experiment but not in the second. The just inference from these ruthless experiments is that whatever happens by way of reaction requires the presence of an uncut sciatic plexus; this organ is therefore part of the cause both of the movement of the leg and of the man's pain. The quite unjust inference is that the pain was "nothing but" a physico-chemical event, whether in the leg, the sciatic plexus, or the brain; unjust because we have not *observed* the pain. We have only the man's own word. If I perform the experiment on myself, knowing that I cannot deceive myself, I still cannot *observe* the pain. But science deals exclusively with facts of observation and with inferences therefrom. The possibilities of enlarging our knowledge of the nature of the nervous mechanism are endless; but the possibilities of extending that knowledge into the realm of consciousness are nil.

Once we admit the existence of two disparate realms of facts we preclude once and for all the possibility of any form of materialistic monism such as Haeckel's. It simply means

that once again we have come up against the restricted character of all scientific explanation resulting from the well-known, but so often forgotten, restrictions which are the essence of its method. I shall have more to say about this later; meanwhile, having determined what must be the limitations of our immediate enquiry, to that we must now return.

Since we have agreed to leave out of the present discussion any reference to consciousness, what remains to be brought into unity with the rest of nature is behaviour; behaviour, whether of the amoeba or of man, in so far as it can be studied independently of consciousness.

If we observe such simple organisms as Paramecium we soon recognize, as did Haeckel, that even this minute creature, devoid of any recognizable structure which could do duty as a brain, possesses a rudimentary intelligence. By intelligence I mean the power of varying motor discharges in the effort to accomplish some end. (It is difficult to avoid the use of anthropomorphic terms without becoming wearisome and vague.) If in the path of a swinging pendulum you place a rigid object, the pendulum will strike and rebound from it until its energy is finally dissipated. Not so with a paramecium; one or two attempts may be made to penetrate the object, but if these fail a new path will be tried. Again, if the temperature in a region be progressively increased, the ciliates will at first tend to congregate in the warm spot, but when it becomes "too hot for them" they will seek the cooler parts. All these reactions are evidently teleological in the sense that they have for their purpose the maintenance of life; moreover, they are not

merely that maintenance itself. This I reckon to be the beginning of mind. And as we ascend the scale of life we find that just as the apparatus of nutrition and of reproduction tends to become segregated in special organs and systems of organs, so it is with the apparatus for the interaction with the environment, that is, the apparatus of "mind." Moreover, nowhere is there a break in the chain, only—between the apes and man—an enormous expansion of mental powers. Whether this sudden increase in mental power is accompanied by the abrupt appearance of consciousness is not for us to determine, even if we could. From the observed resourcefulness, and what appears to be reflectiveness, of apes and dogs, it seems highly improbable that some degree of apperceptive consciousness does not exist in them; but either way, there is nothing to gain by the dualism which postulates the special creation of a human "soul."

We may conclude, therefore, that "mind" has arisen and developed *pari passu* with organism. If organism can be accepted as one with inorganic nature, then so can mind, seeing that, consciousness always being excluded, it is merely one of the activities which characterize all living creatures.

There are, however, two aspects of this solution which must give us pause, namely, in the first place, the lack of parallelism between the mental advance from ape to man and the corresponding advance in bodily fitness, and, in the second place, the absence of any strict correlation between size of brain and intelligence. The former problem has been elucidated by General Smuts (*op. cit.*, p. 242) as being the sudden predominance of the individuation factor at the

expense of the regulative, which heretofore has been the dominant force in the evolutionary advance. Whether this constitutes any sort of explanation I doubt; I do not imagine that General Smuts would make any such claim himself; but it certainly helps to "place" human mind in the evolutionary scale. It is also possible that my remarks on the second problem may shed some light upon the first.

The fact that a very large brain does not necessarily imply pre-eminent intellect considerably weakens both the materialistic position, that the mind is nothing but the activity of brain considered under a different attribute, and also the dualistic view that the brain is the machine by which the soul executes its designs; it is neutral, however, with respect to the view that I am upholding, namely, that those activities conveniently lumped together as mental are properties of the organism itself on a higher emergent level than those concerned with metabolism and reproduction *per se*. This neutrality is explained by the fact that mental activity is learned by repetition. Now it is not to be supposed that a new association necessarily implies a new unit of material structure, it is rather to be explained as an increase in the ease of flow of the nerve impulse through various ganglionic connections. If this be so the whole nervous system is implicated; moreover, the change is likely to be due rather to an "activation" than to the growth of new structures. The extension of Professor Pawlow's epoch-making experiments on conditioned reflexes may be expected to confirm this view; though it must be clearly understood that the so-called "behaviouristic" psychology which teaches that only these reflexes, and the more complex

associations which seem susceptible of explanation in terms of them, can be true objects of knowledge in the realm of mind is in my view likely to exert as cramping an influence on psychology as mechanism is doing on biology. I cannot pause to defend this view, but my general reasons should be evident from the whole tenor of my discussion on the problem of knowledge.

I think enough has been said to show that no insuperable obstacle need stand in the way of our acceptance of the unity of life and mind; indeed, the evidence for its possibility is also that of its actuality. Admittedly only the bare framework has been laid down, and it may well happen that advances in comparative psychology may show up the weakness of the joints. Nevertheless it is of striking significance that the most successful attempt which has been made to order the phenomena of consciousness by the application of the self-same methods that have proved their worth in the study of other departments of nature has come to postulate a link between the organic responses and those of consciousness similar in nature to that outlined above (*cf.* Bernard Hart, *The Psychology of Insanity*, 4th edn., Chap. XI. While agreeing with this author on the necessity for not confusing "brain cells" with "ideas," I do not share his views on the nature of concepts in general; *vide op. cit.*, p. 16).

Though foreshadowed by von Hartmann (*vide supra*, p. 152 *et seq.*) and utilized later by Haeckel (*vide supra*, p. 249) the conception has been given the explicitness possible only when backed by experimental data (since the psycho-analytic technique seems to me to come within the definition

of experimental enquiry) by Dr. Freud. He regards consciousness as arising "in the place of the memory-trace" (*Beyond the Pleasure Principle*, trans. from 2nd. German edn., 1922, p. 28), in the cortical region of the brain, this region being that which in the evolution of the organism has "been so burned through by the effects of stimulation that it presents the most favourable conditions for the reception of stimuli and is incapable of any further modification" (*op. cit.*, p. 29). Dr. Freud continues: "Applying this idea to the system Bw. [*i.e. Bewusstsein* = consciousness], this would mean that its elements are not susceptible of any further lasting alteration from the passage of the excitation, because they are already modified to the uttermost in that respect. But they are then capable of giving rise to consciousness" (*op. cit.*, p. 29). He prudently adds: "In what exactly these modifications of the substance and of the excitation process in it consists many views may be held which as yet cannot be tested" (*op. cit.*, p. 29).

This speculation is in no sense an explanation of consciousness, but is in harmony with the observed facts that consciousness "resides in" the cerebral cortex, and that the whole nervous system is developed from the epiblast or embryonic ectoderm (*i.e.* that part of the organism in closest contact with the source of external stimuli); it is strengthened by the independently enunciated theory that phylogeny repeats ontogeny; and it serves to explain the view based on the experimental results of psycho-analysis, that memory has its seat in a different "level" of the mind from that of consciousness. (The meaning of this was set forth in the earlier work *The Interpretation of Dreams*, particularly

in the section on "The Psychology of Dream Activities.")

But this is not all. Early in its evolution we see the organism "creating a shell" about itself so that its vital part may not be constantly at the mercy of external stimuli. Nevertheless portions of it penetrate the dead outer layer, so that the organism may be aware of its environment; in the higher organisms these portions are the highly complex sense organs, each specialized for the reception of a particular kind of stimulus, and allowing only small samples, as it were, to reach the centre. At the same time the cortical layer of this central system, which receives the stimuli, is at the mercy of the excitations from the deeper levels of whose content the organism is not conscious; hence arises the tension between the inner and outer worlds of the organism into whose consequences we need not enter (*vide Beyond the Pleasure Principle*, p. 30 *et seq.*).

This explanation is dualistic in the sense that the inner and outer worlds are frequently antagonistic to one another, and the dualism is heightened by Dr. Freud's postulation of the "censor," which smacks too much of entelechy. But if the development of analytical psychology should show the redundancy of this concept (about whose necessity Dr. Freud himself is guarded) we may regard the theory as being of the greatest promise for the future merging of the physical and mental realms in one unitary concept of evolving and organized being. An interesting variant of this view, indeed a sort of inversion, namely, that life is the result of matter acquiring the power of memory, was put forward by Samuel Butler and revived recently by the late Professor Rignano.

CHAPTER XXIII

UNIVERSE

THE universe of which I shall here speak is not the astronomical universe but the *facies totius universi* of Spinoza. If it be objected that the latter includes the former I shall agree, but I shall nevertheless make no attempt to discuss it. And for these reasons.

In the first place, as Professor de Sitter wisely observed in the British Association discussion (1931) on "The Evolution of the Universe," the astronomical universe is an unverified, perhaps unverifiable, hypothesis (*cf.* Emile Boutroux, *Contingency of the Laws of Nature*, trans. 1916, p. 78). Nature beyond our earth consists of stars, planets, nebulae, and the like: these are our facts. That the "space" which contains them is limited in extent is a hypothesis based on the convergence of many lines of argument; on the distribution of stars, on the one hand, and the interpretation of a certain quantity in the relativity equations as the reciprocal of the square of the radius of curvature of the hypersphere, on the other. This interpretation is not forced upon us by any independent set of facts, but is dictated by the particular philosophy of the spatio-temporal continuum at present fashionable among the leaders of physical thought.

In the second place, it appears that this view of the universe is not only an hypothesis, it is also a rather questionable hypothesis; for evidence from another

source,[1] namely, the displacement of the spectral lines from the extra-galactic nebulae, which in a homogeneous universe can mean only the regression of those nebulae, indicates that the universe is "expanding," which incidentally explains what becomes of the energy of radiation poured out by the stars. Now there is nothing inherently contradictory in a closed universe and one which is expanding; but unfortunately it is expanding much too fast, that is, it must have started expanding much too recently, to allow for the time required for the evolution of the galactic systems from an undifferentiated nebula.

Before dismissing these two hypotheses we should do well to bring into the light the assumptions which underlie them, and are apt to pass unnoticed. There are probably a great many such assumptions, but it will suffice for my purpose to consider two: these will be sufficient to show that no good purpose can be served by attempting to incorporate the present cosmological hypotheses into any *Weltanschauung*. The first assumption is cloaked by the word "homogeneous" in the above paragraph. It is true that no other explanation than the one given can be accepted provided that the laws of physics in the spiral nebulae and in the space between them and us are the same as those which we have discovered in terrestrial laboratories. It was, in the first place, to keep them true that the theory of relativity was put forward; that is, the universal truth

[1] It should be pointed out that both Abbé G. Lemaître and Professor de Sitter have given mathematical demonstrations of the instability of the universe, the former from the relation between the size and the quantity of matter it contains, the latter from the inherent properties of space-time.

of an unambiguously demonstrated physical law is regarded, and rightly so, as dogmatic—apart, that is, from the slight uncertainty in every law based upon induction. But what has also been assumed in the term "homogeneous," and with I think less justice, is that no other laws, as yet undiscovered, can be causing what Mill called "intermixture of effects." (As, for instance, the unsuspected cosmic rays, which have been causing profound changes all around us, without any indication of their presence arising in the ordinary routine of physical measurement.) Of course it is quite useless to postulate any such "laws" merely to cover up contradictions in the existing hypotheses; what I am urging is the danger of attributing certainty to any inference with regard to phenomena on the cosmical scale, however unquestionable such inference might be on the terrestrial scale.

The second assumption, which is closely connected but not identical with the first, is that we may extrapolate in both time and space without any danger of error. Only an extremely small fraction of the inferred universe can be observed at all by us; hence any theory as to the evolution of the universe as distinct from those members of it which are observable must be outside the realm of science altogether. The matter has been put by Professor de Sitter in words which are well worth quoting: "All assertions regarding those portions of the universe which lie beyond our neighbourhood either in space or in time are pure extrapolations. In making a theory of the universe we must, however, adopt some extrapolation, and we can choose it so as to suit our philosophical taste. But we have no right to expect it to be confirmed by future observations extending

to parts now outside our reach" (Report of British Association Discussion, *Nature*, October 24, 1931, p. 708).

The dangers of these two assumptions are not merely academic; one has recently been exemplified in the history of science. Half a century ago the physicists could hold out no hope that the age of the earth was great enough to account for geological evolution; and simply because the calculations, though perfectly valid with respect to the existing laws of physics, failed to take account of the then unknown radioactive elements whose energy was being poured out on all sides without the physicists being any the wiser. So much for "scientific certainty."

In a recent discussion (see *Nature*, September 30, 1933, p. 502) Professor de Sitter has indicated another way out of the difficulty, namely, that there need be no paradox in the assertion that "the stars are older than the universe"; for the stars may have existed before the universe attained the sort of configuration upon which our calculations are based.

I shall leave, then, the consideration of the universe as modern mathematical physics presents it to us, and address myself to the exceedingly difficult task of attempting some general conclusion as to the relation now subsisting between natural science and monistic philosophy. The task is made the more difficult seeing that not only is a good deal of repetition inevitable in order that we may grasp the problem in its totality, but I am afraid that we shall find that many of the parts of our discussion will have to be modified when viewed in the fuller light of the whole; though this may be partly due to a lack of intel-

lectual grasp on the part of the author, it is also part of the intrinsic difficulty of the subject, a result, that is, of what our discussion has all along aimed at showing, namely, that knowledge must commence with dissection, but must end, if ever, with synthesis of the parts, not only as parts, but with respect to the relations discovered as subsisting between them.

As a result of our analysis, in the light of the data that science delivers to us, of the various components of nature, we have concluded that living things and their minds, no less than the eternal hills, the waves, and the winds, together with all the host of heavenly bodies that we have observed, contain no other "material" units but protons and electrons. But since we have strenuously opposed the further inference that the wealth and beauty of nature are "nothing but" a dance of these electric charges, we have had to search for some alternative relationship whereby the poverty of this view might be excluded without the opposite attitude having to be merely accepted as a whole with "natural piety." I have already in the preceding chapters of this Part given some hints as to how this dilemma has arisen in the various departments of natural knowledge. We have now to apply these principles to nature considered as a whole; to discover whether the resulting concept of nature is consistent with the epistemological and psychological views urged in the Third Part; and finally to determine to what extent it can be regarded as monistic.

When we say that life and mind are reducible to material complexes and forms of energy in the same way as the latter are to electrons and protons, we mean this quite

precisely; that is, we assert that nothing measurable can be extracted from any of these by the most refined experimental methods except protons, electrons, and quanta of energy; further, since protons and electrons are electric charges, and electricity is a "form" of energy, everything on earth and in the observable heavens appears to be ultimately reducible to energy, though how the dualism of the electron-proton relationship is to be resolved we cannot yet see. Perhaps if we could discover how the one substance, energy, could determine itself to activity by this "attunement of opposite tensions" we should see "how what is at variance agreed with itself," and the problem of being and becoming, of diversity in unity, might, at least within the scientific realm, be solved. Perhaps, however, this ultimate residuum is the final dualism left after our monistic desires have had their way. In any case, speculation is here out of place.

Nothing measurable, then, can be found in nature but those scientific objects mentioned above. But, by confining itself to the measurable, or rather by defining the substance of things as that which is measurable in them, science has simply left out of account all the other qualities that go to make a world. If we were asked by a Martian scientist to tell him what a thing called a "moonlight sonata" was made of, we could with great labour and skill describe to him every combination of vibrations in the air set up by striking pieces of metal with padded hammers. Being possessed of superlative mathematical insight, he would delight in the regularity of the functions displayed by analysis of the harmonies and overtones; he might even write the

equation representing it; but if nature had endowed him with no sense of sound, he would be deprived inevitably and absolutely of the understanding of this "thing" such as is possible to any human child. It will at once be objected that this example involves the higher levels of consciousness, but the same argument *mutatis mutandis* stands for what a piece of copper is made of. It is "made of" protons and electrons, because these only are susceptible of measurement; its reddish-golden colour, its response to the hammer, its potentiality for dissolving in acids to form powerful poisons, and of taking on in the flame the colours of the sunset or the storm—these cannot be measured; therefore, so far as the "stuff" composing it is concerned, they do not exist.

As M. Emile Meyerson has pointed out, the reduction of the infinite variety of material forms to one or two primordial substances is ultimately the reduction to empty space, that is, nothing. According to him, and I find his argument entirely convincing, this comes about owing to the tacit assumption by men of science of the "plausible" dogmas of inertia, conservation of matter, and conservation of energy, all of which are merely aspects of the ontological principle of causality, namely, that the only explanation of change is the demonstration that no "real" change has occurred. So long as each successive state can be shown to to be merely a rearrangement of the substance already there, to that extent has a "scientific" explanation been effected; but it is only by the rejection at every stage of characters which are significant for other viewpoints that this can be achieved. We cannot stop short even at electric charges, for

the general theory of relativity indicates that the only character which these share with matter, that is inertia, can be accounted for by assuming a discontinuity in space-time; consequently, as we have already been told by many who know all about these things, space-time is the only reality, all else "nothing but" warps and crinkles in it. This is a sorrowful state of affairs, but hope sinks even further when we consider that the denial of any real change means the denial of any time flux, for if time is non-existent we are left with space. With this we are back at the position to which "with the prodigious vigour of his intellect, Descartes, in this question as in many others has gone at one bound to the limits of human thought" (*Identity and Reality*, p. 247). Indeed, with the acceptance of a spherical universe we are back a good deal further, namely, at the One of Parmenides in which the whole phenomenal world vanishes as mere illusion. If as the result of three hundred years of feverish study of phenomena all that science can tell us is that they do not exist, Socrates was certainly right in regarding it as the sport of fools. This sublime *reductio ad absurdum* does not, however, invalidate at all the results of science, but only the false interpretation put upon them.

Before leaving this matter, I must mention an alternative result of the same line of argument as that which ended so disastrously for the phenomenal world; this is the view which Sir James Jeans has recently advocated, namely, that "the universe can be best pictured, although still very imperfectly and inadequately, as consisting of pure thought, the thought of what, for want of a wider word, we must describe as a mathematical thinker" (*The Mysterious Uni-*

verse, p. 136), and "It exists in a mathematical formula; this, and nothing else, expresses the ultimate reality" (*op. cit.*, p. 142). (This quotation actually refers to the wave-system of an electron; but I take it that it applies in principle to the universe.) I do not want to criticize this in detail, because a universe which can best be pictured as pure thought and is yet not idealistic throughout (*op. cit.*, § 4, p. 137) seems to me nonsense; I can only suppose that the real meaning of Sir James Jeans has escaped me. But apart from this, I cannot help feeling that the hypostasis of mathematical formulae is based on just the same error as that which led to the hypostasis of space, namely, the failure to recognize that the final subsumption of nature under a system of mathematical formulae is arrived at only by rejecting at every stage all those data which mathematics is unable to handle. This result has been arrived at by the method of enquiry known as mathematical physics, which deals with the numerical relationships subsisting between those properties of things which are capable of such relationships, and it deals with nothing else. Is it surprising, then, that all the results it yields us are relations between numbers, or symbols representing the classes of such relations? The whole matter was shown up by Sir Arthur Eddington some years ago; unfortunately the minds of great investigators seem to work sometimes in the same way as he so brilliantly demonstrated for mathematical physics, namely, in closed systems.

These interpretations of nature, monistic in principle, we can in no wise accept; for although they have shed the material trappings of eighteenth-century materialism, of

nineteenth-century mechanism, of Haeckel's evolutionism, they are but shadows of the reality that we call nature. As Professor Whitehead has said, "There can be no true physical science which looks first to mathematics for the provision of a conceptual model. Such a procedure is to repeat the errors of the logicians of the Middle Ages" (*Principle of Relativity*, p. 39).

We may approach the matter from both ends. Let us start with those entities which for science are the simplest, and we shall see at once that even physics has not been able to divest them of all being other than merely symbolic. The electron and the proton, we are told, are both most easily pictured as groups of waves; we are also told that they need not be, that some physicists, indeed, prefer not to picture them at all; but for my part I cannot see that science is telling us anything of much value if its last word is one with no meaning. I must elaborate this a little before passing on, otherwise I may lay myself open to gross misconception. By demanding some meaning I do not, of course, imply that the last step in the mathematical argument may not quite properly be, as every other step certainly will be, quite unintelligible to *me*; all I ask is that it may be intelligible, and not merely mathematically intelligible, to the mathematician whose business it is to interpret it. Let me illustrate by an example. When Newton found that adequate verification of his hypotheses involved the masses of bodies whose diameters were not negligible in comparison with their distances from one another, and that these bodies moved not in circles at uniform speeds, but in ellipses at speeds which varied from moment to moment, he had to

invent the "inverse method of tangents" and the "fluxional calculus," which not one in a hundred of the learned of his day could possibly understand; but his results were clear in their deliverance, namely, that every particle of matter attracts every other with a force inversely proportional to the square of the distance between them. It not only had meaning, but was, and is, provided we clearly recognize that the attractive force is not a sort of grappling-iron, true or very nearly true. As Professor Alexander urges, "Once true, always true," within the restriction of the then known facts (*Space, Time, and Deity*, Vol. II, pp. 263–4). I do not ask, indeed my reference to the "grappling-iron" clearly shows that I strenuously oppose, that space should be, in the delightful phrase of Sir Arthur Eddington, "filled with the hum of machinery," but I cannot believe that science is doing itself justice unless it can express its results in terms of intelligible conceptions; by intelligible conceptions I mean what I think Leibniz had in mind when he wrote: "Terminological expressions in mathematics are most helpful when they express the inmost nature of the matter shortly, and as it were give a picture of it" (quoted by P. Lenard, *Great Men of Science*, p. 115). Or to put it in another way, once it fails to effect this translation, and admits that unreal quantities enter into its pronouncements, it is high time that, as Sir James Jeans admits at the end of his book, "it should leave off making pronouncements."

Seeing, however, that the picturing of the electron as a group of waves is not categorically forbidden, I shall emphasize, humbly echoing Professor Whitehead's remark, that "the electron is its whole field of force" (*The Concept*

of Nature, Chap. VII). In the same chapter Dr. Whitehead suggests that a minimum quantum of time may be necessary for the existence of the electron. I also agree with General Smuts, that physics has thus confirmed Faraday's conception of the charge of electricity being actually the lines of force which he pictured spreading out from it; confirmed, extended, and refined it. Refined it, in that it has given it quantitative significance; extended it, by demonstrating the temporal element involved. For, as Dr. Bavink puts it, "an electron does not simply exist, it happens" (*op. cit.*, p. 200). The electron can therefore no longer be justly regarded as an atom of electricity except in so far as the old conception of the physical atom must be enlarged correspondingly; it is a pervasive factor in space-time, and seeing that it is non-homogeneous with respect to time (for such I take to be what is essential in the concept of "wave"), it is a structured object. Now if once this be granted, it is a result of the highest importance, for it tells us that however deeply we probe into nature's secrets, the simplest entities we can discover are still non-homogeneous, that is, they are not "vacuous actualities," to borrow a phrase from Professor Whitehead.

One part of the dream of Leibniz, that in which he pictured worlds within worlds, has thus been realized; but a moment's reflection will show us that the other part, the participation of each in all, is also involved. So long as the atom was a "hard, massy, particle," its isolation was perfect, its interaction with its fellows a miracle; but now that it and its components, which for a time superseded it as "massy particles" of electricity, are fields of force, isolation is

impossible. The undeveloped hint given by Locke when he said, "We are quite out of the way when we think that things contain within themselves the qualities that appear to us in them," was given more explicit statement by Leibniz in the famous dictum that "Every monad mirrors the universe"; now with the full weight of scientific evidence concerning the simplest recognizable units behind us, and in the fuller understanding of the relations between space and time, we may generalize the statement and say with Professor Whitehead: "In a certain sense everything is everywhere at all times. For every location involves an aspect of itself in every other location. Thus every spatio-temporal standpoint mirrors the world" (*Science and the Modern World*, p. 128).

This result in its totality enables us to move upwards from the electron to the atom, from the atom to the chemical compound, and so to life and mind; for if the electron consists of a structured field, so much the more must its compounds, the chemical atoms; that they in their turn do so is implicit in the electronic concept of chemical combination, whether in the neutralization of residual fields in polar compounds, or in the common field of co-ordinated compounds with shared electrons. Once the structured nature of the ultimate parts is granted, the emergent qualities of the compounds is no longer a mystery; although this theory cannot show *how* emergence occurs, it shows as Poincaré said of Maxwell's theory, its possibility, which from an aggregation of structureless units might always be doubted. On the same analogy we can see how the emergent quality of life is possible, seeing that every chemical com-

pound is not merely itself alone, but the sum-total of its relations with everything else.

This theory gives a deeper insight into the meaning of Aristotle's illustration of how from the same letters either a comedy or a tragedy might emerge. For letters are not, like the atoms of Leukippos and Demokritos, "vacuous actualities," whose relations, unless hypostasized and thus given a spurious reality, are meaningless. On the contrary, letters are symbols for things which *are themselves potential relations*; that is, stripped of their relations they are nothing. Nevertheless they may be recognized within the concrete (words), which have an emergent meaning of a low order; they, in their turn, depending largely for their reality on their potential relations, which become actual in the sentences from which the words may be abstracted.

The entities of science, then, must be regarded as possessing the same kind of structure as the things of the mind; and with respect to these latter the process of abstraction at once introduces an element of unreality. As Professor Lossky points out, with regard to a musical note, we distinguish its quality from its intensity. "It would never occur to anyone that the quality and the intensity had first existed on their own account, separately from and independent of one another, and then come together, forming a more complex whole—a musical note" (*The World as an Organic Whole*, p. 17). But it *has* occurred to some people to take seriously the suggestion that points are prior to lines; for though few thoughtful people would seriously argue that a line is merely the sum of its points, yet our geometry books still inform us that a line is traced out by

the movement of a point, which is a perfectly valid conception in itself, provided, as Professor Lossky points out (*op. cit.*, p. 3), we recognize that the movement is more than the sum of successive positions occupied by it; but this has not always been recognized.

We thus come to see that all our conceptions, whether of lines, notes, frogs, copper sulphate, atoms, or electrons, are fragments of greater wholes, and as such misleading. If at first we think we can define them in terms of simpler units, we are soon driven to recognize that the latter are less and less real because more and more relationships are broken in defining them, and these relations are of the essence of themselves. *Omnis determinatio est negatio.* The more an entity approaches to a whole the more easily we can apprehend it; but we cannot define it without losing part of it. This conception of *facies totius universi* as being the *one* thing we can immediately apprehend (though we cannot know all its modes) was first clearly recognized by Spinoza; it was revived by Hegel out of the ruin left by Kant, and extracted from the less acceptable parts of Hegel's system by Bosanquet, under the name of "concrete universal." The return to this mode of interpreting the findings of natural science, and thus harmonizing them with the wider fields of man's experience, is fraught with the utmost consequences for the future of humanity. The philosophical works which have been mainly responsible for providing the basis of advance in this New Learning are in my opinion those of Professor Whitehead. In the attempt to elucidate some of the difficulties which still remain, I shall be guided mainly by his always suggestive thought. In parenthesis I must

candidly admit my wholly inadequate grasp of his system. It has been held, and with some justice, that Professor Whitehead's writing has patches of profound obscurity; this fact, and with no justice, seems to have been used as an excuse for not taking him seriously; that is, as I see it, as one of the few eternal minds of this chaotic age. The apparent obscurity of those portions of his thought which my untutored mind permits me to meditate upon has on a second or third reading always revealed itself not as darkness but as blinding light; his peculiar terminology is not that of the *arriviste* or obscurantist, but the inevitable mode of expression of thought which phoenix-wise has flown upwards from the ashes of worn-out categories. The freshness, the vitality, the almost epic quality of so much that he has produced in what conventionally would be regarded as his old age, urges a new hope not only for the philosophy of this "brave new world," but for the "societies" of "actual entities" which inhabit it.

This digression was necessary to explain why in what follows I am consciously borrowing much more from Professor Whitehead than from other contemporary philosophers. This thesis makes no attempt to bring the history of the monistic concept "up to date"; it merely happens that in the attempt to clear up difficulties in my own views on the philosophical implications of science I have been more influenced by Professor Whitehead's approach than by any other; it does not follow that I accept, even so far as I understand, his system; it follows even less that my own views are necessarily consonant with his.

The first difficulty we are brought up against in this

organic view of nature is as old as Zeno; how comes it that we apprehend natural objects as continuous, but can explain them scientifically only as composed of discrete quanta? This question will be found to be not unconnected with that of being and becoming; and I shall try to show that both these dilemmas have arisen partly as a result of a faulty evaluation of the subject-object relationship. It will be convenient to take the last-named first.

As I have already indicated, I regard Kant's enunciation of the "synthetic unity of apperception" as the key to the problem of knowledge; here I reaffirm this view, and add thereto the belief that it is the failure on the part of every member of the Apostolic succession to take it seriously that has been largely responsible for the fruitless controversies concerning the respective merits of idealism and realism. My view coincides entirely with that of Mr Hallett when he says: "It is important to remember that a particular thing or quality is never perceived in isolation, but always *in a concrete situation* of which the observer's organism is a central and essential element. . . . From such simple roots springs that vast jungle of epistemological disputation concerning idealism and realism which appears for many recent writers to constitute the main content of philosophy" (H. F. Hallett, *Aeternitas*, 1930, p. 169; italics my own). Now the organic view of nature which we have been led to accept involves just the same result (*cf.* also Smuts, *Holism and Evolution*, p. 247). "Philosophical thought," says Professor Whitehead, "has made for itself difficulties by dealing exclusively in very abstract notions such as those of mere awareness, mere private sensation,

mere emotion, mere purpose, mere appearance, mere causation. These are the 'ghosts' of the old 'faculties,' banished from psychology, but still haunting metaphysics. There can be no 'mere' togetherness of such abstractions. The result is that philosophical discussion is enmeshed in the fallacy of 'misplaced concreteness'" (*Process and Reality*, p. 24). I would add, incidentally, that, so far as I can judge, it is the failure to rid his mind entirely of the tacit dualistic presupposition of the legitimacy of separating the subject and object in essence and not merely ideally in abstraction that is responsible for the fact that Professor Lovejoy's book *The Revolt Against Dualism* (which of course is his own revolt against monism), acute and illuminating as his criticism of detail may be, finally leaves one unconvinced.

In order to make my position as clear as possible I must consider for a moment an actual example—the looking at a red rose. It has been objected that there is "really no red rose" there; that what I see is something else which may be "like" the rose or it may be wholly unlike it. From the commonsense point of view, the universe must be a wholly futile enterprise if every "object" in it has to be constructed by every "mind" that perceives it; but once you grant the legitimacy of separating the two for the purpose of considering just that particular occasion in which they are compresent, some such futility seems to be beyond the ingenuity of man to avoid. Such ideal separation is perfectly justifiable if you are concerned with what Fechner called the *Nachtansicht*, that is, the analysis of an object from the point of view of the outside observer; thus I may take the rose I am looking at and extract its pigments, analysing

them into radiation frequencies, electrons, etc., to my heart's content; but it is the very fact that I cannot be "the outside observer" of the situation "my seeing of the rose" which invalidates any such procedure for that situation. I imagine that some such argument is also implicit in Professor Lloyd Morgan's view that the colour is neither in the mind nor the rose, but in the whole situation (*Emergent Evolution,* Lecture VIII). The further dualism so real to most of us of the struggle between our "lower" and "higher" natures disappears if, with Mr. Aldous Huxley, we recognize it to be an "attempt" of a part to dissociate itself from the personality as a whole (*Do What You Will,* p. 140).

Now I think that by consistently maintaining this attitude throughout our investigation of the relations between "appearance" and "reality" we can in principle resolve the remaining dilemmas that we were faced with. By the expression "in principle" I mean that, since in my view it is the failure to avoid this fallacy of "misplaced concreteness" that is the origin of these dilemmas, they can be shown to disappear on more accurate statement of the problem; if this be so, then much philosophical disputation would appear to be no more than an attempt, impossible of achievement, to resolve the contradictions created by the mind itself. (Compare the views of Lotze quoted on p. 156 *supra.*) I cannot hope that this view will be accepted at its face value; nor on the other hand can I attempt in this work any detailed defence of it; I must content myself with indicating in the barest outline the sort of argument I should seek to develop, and demonstrate by a few quotations the convergence to this point of view manifest in the writings of

several leaders of thought, who in other departments hold divergent views.

The two dilemmas we are concerned with, namely, that of continuity and divisibility, and that of being and becoming, arose in Greece owing to a failure to recognize the subjectivity of time. By subjectivity of time I do not mean that time is "nothing but" subjective distortion of real timelessness; on the contrary, physics presents us with the brute fact of increase of entropy from which there is no escape[1]; even Professor Einstein admits that you cannot "telegraph into the past." "The moving finger writes, and having writ, moves on"; for another position in space-time its writing may still lie in the future, but for us, for whom it *has* written, there is no return. But the time system of each of us is relative to himself. More important, however, is the failure to recognize the invalidity of hypostasizing the time factor abstracted from a situation, and the attempt to analyse that situation in terms of this unreality. In its simplest form it was exposed by Zeno's paradox of Achilles and the Tortoise; but as Professor Whitehead points out, the fallacy is not fully exposed owing to the manifest violation of the canons of mathematics. The spatial separation between Achilles and the animal he seeks to overtake can be made to differ from zero by as little as we please, because, whatever be our view in regard

[1] I am not here concerned with the question as to whether the anticipated consequences can be avoided, but with the ineluctable fact that the entropy of the universe *does* increase. The dualism created by the anticipated "death" of the universe seems at present inescapable; but the principle of Maxwell's demon robs it of dogmatic certainty. (Cf. E. A. Milne, "Some Points in the Philosophy of Physics," *Philosophy*, No. 33, p. 19.)

to time, the time intervals are, in the enunciation of the paradox, made to approach zero; concisely put, the series are convergent. But in the paradox of the arrow in flight the basic error is more nearly laid bare. From the point of view of physiological psychology the grosser aspect of the dilemma may be quite simply resolved. The observer of the arrow is by virtue of his own mental constitution, that is by the nature of his perceptual mechanism, the means of creating continuity of motion whether there be continuity or not in fact; for the whole wealth and glory that is Hollywood could have no existence save for the trivial fact that the human visual sense mechanism cannot distinguish as separate two distinct stimuli following one another with a temporal separation of less than about one-tenth of a second. There is no such thing, then, for perception as an instant of less than this period of time. Thus the specious present that we weave for ourselves is, as Professor Alexander has said (*Space, Time, and Deity*, I, Chap. IV; *cf.* Professor Whitehead, *The Aims of Education*, pp. 189–90), not a present at all; it is merely a way of saying that the mind can retain in immediate perception a finite succession of objects without recourse to memory. The same is true, though not necessarily for similar purely physical reasons, of the perception of sound. Let the note of F natural be struck five times in succession in a singularly simple rhythmical arrangement; to one listener this is but a senseless repetition of one note (with a "trip" between third and fourth); to another, who knows Mozart's Nineteenth Pianoforte Concerto, not only does the whole passage come charged with meaning, but these five F naturals are indi-

vidually different from any single F natural, that is to say, from any part abstracted from the whole situation.

There is, however, a deeper and more general factor in this paradox of Zeno, which is bound up in some measure with the dilemma of Herakleitos and Parmenides. The former, with a singularly powerful glance on the "solid ground of nature," saw that it was far from solid, but in perpetual flux; the latter, unable to see how any real thing could possibly change, swept nature aside as illusion. The dilemma is given dialectical form by Zeno. Professor Whitehead's treatment of this, though rendered uncertain in its exact significance by the use of unfamiliar terms, seems to me nevertheless so illuminating that to avoid any distortion I quote his own words: "The *res vera* in its character of concrete satisfaction is divisible into prehensions which concern its first temporal half and into prehensions which concern its second temporal half. . . . A prehension, however, acquires subjective form, and this subjective form is only rendered fully determinate by integration with conceptual prehensions belonging to the mental pole of the *res vera*. The concrescence is dominated by a subjective aim which essentially concerns the creature as a final superject. This subjective aim is this subject itself determining its own self-creation as one creature. Thus the subjective aim does not share in this divisibility" (*Process and Reality*, p. 96). I cannot pretend to know *all* that Professor Whitehead understands by this passage, but I feel that it is a general principle of organic unity in cognition from which my views on the nature of perception could be derived as a special case (*vide supra*, pp. 391–3).

The meaning of the above citation is best derived from a consideration of its application to the more general question of being and becoming rather than with reference to the particular problem posited by Zeno; this is, in fact, Professor Whitehead's own procedure. Light may be shed on it from two points of view, one of which, if I mistake not, was that of Spinoza, and the other that which modern physics has compelled us to adopt. The former is the concept of subject-superject, which I understand to assert that a "subject" apart from its experiences is in fact nothing: "An actual entity is at once the subject experiencing and the superject of its experiences"; from which it follows that since the "superject" aspect constantly changes, so does the "subject." Now time belongs to the subject-aspect,[1] hence, although that which becomes is temporally extended, the act of becoming which is conditioned by the superject is not so extended, consequently indivisible. This concept seems to me to differ little from Spinoza's statement that "the human mind has no knowledge of the body, and does not know it to exist, save through the ideas of the modifications whereby the body is affected" (*Ethics*, II, 19). (A full interpretation of this passage is given by Mr. Hallett in a note which is unfortunately too long to quote—*Aeternitas*, p. 52, note 2. On the general similarity between Spinoza's and Professor Whitehead's philosophies, *vide infra*, p. 399 *et seq.*)

[1] I find no categorical assertion to this effect in connection with this concept, but I infer the justice of this assumption from the following passage: "I suggest, however, that time and space embody those relations between objects on which depend our judgment of their externality to ourselves" (*The Aims of Education*, p. 237).

The development of the relationship between being and becoming from the point of view of natural science derives from Locke's observation of the ideal limits placed upon the material composing an object such as a tree; this is wholly supported by the evidence of modern science, though the materials are now expressed in terms of entities of higher abstractness. As Professor Whitehead says, "Nor is it true that a perceived object always corresponds to the same group of molecules. After a few years we recognize the same cat, but we are thereby related to different molecules" (*Aims of Education*, pp. 186, 187). There is, as it were, a constant flux of the actual entities of a lower grade of society through the enduring (but not eternal) "form" of the cat.

If we accept this statement of the ideal nature of perceptual objects, and I think the logic of it at any rate *sub specie durationis* is inescapable, we must with Professor Whitehead categorically assert the primacy of process and the derivation of the objects of common sense therefrom by a purely abstract delimitation conditioned by the spatio-temporal "speciousness" of our perceptual faculty. The process so enthroned is very far from being the mere passage of events; it is the active essence of all actual entities. "*How* an actual entity becomes constitutes *what* that actual entity *is*; . . . Its 'being' is constituted by its 'becoming'" (*Process and Reality*, p. 31; *cf.* General Smuts: "The Physical stuff of the universe is therefore really and truly Action and nothing else"—*Holism and Evolution*, p. 335). It is the ground which expresses itself as both efficient and final causation.

Our task draws to an end. While urged to a belief in a

nisus to monism in the data and tendencies of natural science we were faced, on the one hand, by the necessarily partial evidence which even a perfected "scientific monism" can bring in support of a monism of reality; and, on the other, with those major dilemmas the nature of whose solution depends upon the deliverances of physics with regard to space, time, and the "actual entities," and in turn determines the possibility of a monistic philosophy. We have seen, in broad outline only, the sort of solution which modern thought proposes; but even if the basis of this solution be accepted, there is no question but that its application would raise difficulties, for the removal of which the present writer claims no sort of qualification.

If, as has been urged above, it is the system of Spinoza which must be regarded as the pattern of every future monistic philosophy, it is fitting that we should return for a moment to him, in order that we may judge to what extent the philosophies founded on the full acceptance of modern science resemble or depart from his.

Nothing could be nearer to Spinoza's thought than the introduction into this philosophy of the concept of concrete universal—the recognition, that is, that nature, which includes man, is an organic whole in which no individual, however high or low in the scale of value, can be wholly known, if at all, in isolation from that whole; but knowledge of which *in abstracto* is nevertheless *real* knowledge of the individual, though incomplete. The "nature," which is the object of science, is to be identified with the "substance" (= concrete universal) of Spinoza conceived under the attribute extension, the individual entities being

the modes thereof (*cf.* "The experience enjoyed by an actual entity is that entity *formaliter*"—*Process and Reality*, p. 71). If this be accepted, we at once see the problem of causation in a new light. For just as one mode cannot be the efficient cause of change in another mode, so one natural phenomenon cannot be regarded as the cause of change in another. As Professor Whitehead points out, the problem of science is not "Why do we see red when a coal burns?" but "When red is found, what else is found?" "Science is concerned not with the causes but the coherence of nature" (*Concept of Nature*, Chap. II). The dilemmas which have arisen in regard to causation are due to a confusion similar to, but not identical with, that which caused the dilemma of being and becoming. For Spinoza, causation in the true sense is the objectification of the essence of substance, which is eternal, "eternal" in the sense which Mr. Hallett urges is the only one Spinoza could have meant, that is, not timeless, but the concrete essence which is determined to "duration" or "Time" by the *partialitas* of the modes (*Aeternitas*, Chaps. I, II, III). Necessary sequence in time is likewise but the determined correlation of the modes in time. This view, though not differing radically from Professor Whitehead's, is approached more closely by Professor Lossky in his relation of the world to the Absolute (*World as an Organic Whole*, p. 68).

Concerning the relation of mind and body I have no more to say. I have already (p. 397) pointed out the marked similarity between Professor Whitehead's views and those of Spinoza, expressed as they are, one in the language proper to post-Kantian thought, the other in the terms familiar

to those bred in the Scholastic tradition. Here, let me add, by the way, that though Spinoza never entirely freed his language from these terms, their connotation had become much enriched by passing through his mind; and it occurs to me in this connection that Professor Whitehead may possibly have slightly exaggerated the importance which the "subject-predicate" form of argument had for Spinoza. So far as I can grasp it, the full content of the latter's thought always presents itself as an immensely dynamic product bursting the shell in which it was conceived, whence the long scholia and appendices. In a paper which was written for the Aristotelian Society in 1926, and published in their *Proceedings* in 1927, Professor Wolf first advocated a dynamic interpretation of Spinoza's philosophy, as against the then generally accepted logical, Platonic, or static interpretation; and the plea has been repeated by him several times in his subsequent writings. After reading these, and Professor Hallett's *Aeternitas* (1930), I am persuaded to believe that the apparent relationship of ground to logical consequent, which Ward singled out as the central weakness of the system, was not conceived as such, that is statically, by Spinoza. Once again the whole question turns upon the meaning of "eternal." If it is accepted in the sense which I have already indicated, then there is no option but to express the relation of *natura* to the modes as a *nisus* of grounds to consequents, since any other transition involves the time factor, which if it formed part of the conception of *natura* would detract from its perfection. One may regard this restriction on the mode of relationship as a weakness, without implying any *confusion* in Spinoza's

mind; but if it be admitted, as I think it may, that logical priority, though certainly timeless, may be, as Mr. Hallett puts it, the identity of achieving and achievement *sub specie aeternitatis*, then the last nail has been struck into the coffin of that ill-gotten monster, the acceptance of Spinoza's philosophy as "logical pantheism" (*vide* also p. 294 *supra*).

When all is said and done, however, though Spinoza's system remains the one perfect monism, to the pattern of which any true monism must conform, there seems to me at present insufficient understanding of the relations between the actual entities of the world and the felt but imperfectly conceived substance of which they are the modes to justify opposition to Professor Whitehead's acceptance of them as the "sheer actualities," whose "analysis increases our understanding," but "does not lead us to the discovery of any *higher* reality" (*Process and Reality*, pp. 8, 9; italics my own). His system is therefore a substantival pluralism, in which the "prehensions" bind the elements into a systemic monism.

Natural science, then, and the philosophy based on it, gives us strong hope that the goal to which it is approaching is the ONE which has been the starting-point of many speculative philosophers. But it has been the delivery of science, no less than that of critical philosophers, that the ONE which it conceives is neither the dead nonentity of Parmenides, the living but mechanical abstraction of Haeckel, nor the formal lofty absolute of Hegel. It is the ONE in which *natura naturans* expresses itself eternally as *natura naturata*; where the misted hills and the atoms composing them are

alike real, alike limited by partaking of duration; where the mind of man will at length understand, as his love *sub specie aeternitatis* has always felt, that

> The One remains, the many change and pass;
> Heaven's light for ever shines, Earth's shadows fly;
> Life like a dome of many-coloured glass,
> Stains the white radiance of Eternity.

SELECT BIBLIOGRAPHY

Alexander, S.: *Space, Time, and Deity*, 2 vols., London, 1920.
Spinoza (Tercentenary Lecture), Manchester, 1932.
Bacon, Francis: *Advancement of Learning*, 1605, etc.
Novum Organum, 1620, etc.
Ball, W. W. R.: *History of Mathematics*, London, 1888, 4th ed., 1908.
Bavink, B.: *The Anatomy of Modern Science*, London, 1932.
Berkeley, G.: *Essay Towards a New Theory of Vision*, 1709, etc.
Three Dialogues between Hylas and Philonous, 1713, etc.
The Principles of Human Understanding, 1710, etc.
Bosanquet, B.: *The Principle of Individuality and Value*, London, 1912.
Boutroux, E.: *The Contingency of the Laws of Nature*, London, 1916.
Boyle, Hon. R.: *The Sceptical Chymist*, 1661, etc.
Bradley, F. H.: *Principles of Logic*, 2 vols., Oxford, 1922.
Appearance and Reality, London, 1893, etc.
Broad, C. D.: *Scientific Thought*, London, 1923.
The Mind and Its Place in Nature, London, 1925.
Brunschvicg, L.: *Spinoza et Ses Contemporains*, 3rd ed., Paris, 1923.
Buckley, H.: *A Short History of Physics*, London, 1927.
Burnet, J.: *Early Greek Philosophy*, 3rd ed., London, 1920.
Cajori, F.: *History of Physics*, 2nd ed., New York, 1929.
Carr, H. Wildon: *Leibniz* (Leaders of Philosophy Series), London, 1928.
Clodd, E.: *Pioneers of Evolution*, London, 1907.
Cornford, F. M.: *Before and After Socrates*, London, 1932.
The Laws of Motion in Ancient Thought, London, 1931.
Darwin, C.: *The Origin of Species*, 1859, etc.
Descartes, R.: *Philosophical Works*, translated by Haldane and Ross, 2 vols., Cambridge, 1911.
Drews, A.: *Der Monismus*, 2 vols., Jena, 1908.
Driesch, Hans: *The Science and Philosophy of the Organism*, 2 vols., London, 1908.
The History and Theory of Vitalism, London, 1914.
Eddington, A. S.: *The Nature of the Physical World*, Cambridge, 1928.
Space, Time, and Gravitation, Cambridge, 1921.
Einstein, A.: *The Theory of Relativity*, 4th ed., London, 1921.
Eisler, R.: *Die Geschichte des Monismus*, Leipzig, 1910.
Erdmann, J. E.: *History of Philosophy*, 3 vols., London, 1892, etc.
Fischer, Kuno: *Descartes and His School*, London, 1887.

FREUD, S.: *The Interpretation of Dreams*, London, 1913.
Beyond the Pleasure Principle, London, 1922.
FREUNDLICH, I.: *Einstein's Theory of Relativity*, London, 1924.
GIBSON, A. B.: *The Philosophy of Descartes*, London, 1932.
GILSON, E.: *Philosophie au Moyen Age*, 2 vols., Paris.
GLAZEBROOK, R. T. : *Clerk Maxwell and Modern Physics*, London, 1896.
GREEN, T. H.: *Prolegomena to Ethics*, Oxford, 1883.
HAECKEL, E.: *Monism*, English translation, London, 1894.
Die Welträtsel, English translation, *The Riddle of the Universe*, London, 1902.
HALDANE, J. S.: *The Philosophical Basis of Biology*, London, 1931.
HALLETT, H. F.: *Aeternitas*, Cambridge, 1930.
HARDIN, W. L.: *The Rise and Development of the Liquefaction of Gases*, New York, 1899.
HART, B.: *The Psychology of Insanity*, Cambridge, 1930.
HARVEY, W.: *Anatomical Disquisition on the Motion of the Heart and Blood*, 1628, etc.
HEIBERG, J. L.: *Science and Mathematics in Classical Antiquity*, Oxford, 1922.
HELMHOLTZ, H. VON: *Popular Lectures* ("The Interaction of Physical Forces" and "On the Conservation of Force"), London, 1904.
HERSCHEL, J. F. W.: *Preliminary Discourse on the Study of Natural Philosophy*, London, 1830.
HOBSON, E. W.: *The Ideal Aim of Physical Science*, London, 1925.
HOERNLÉ, R. F. A.: *Idealism*, London, 1924.
HUME, D.: *Enquiry Concerning the Human Understanding*, Oxford, 1927, etc.
HUXLEY, ALDOUS: *Do What You Will*.
HUXLEY, T. H.: *Evidences as to Man's Place in Nature*, London, 1895, etc.
JEANS, J.: *The Universe Around Us*, Cambridge, 1929.
The New Background of Science, Cambridge, 1933.
The Mysterious Universe, Cambridge, 1930.
JEVONS, S.: *The Principles of Science*, London, 1883.
JOHNSTONE, J.: *The Philosophy of Biology*, Cambridge, 1914.
JUNG, C. G.: *Contributions to Analytical Psychology*, London, 1928.
KANT, I.: *Prolegomena to Every Future Metaphysic*, London, 1915.
Theorie des Himmels.
Critique of Pure Reason, English translation by Meikeljohn, London, 1901.
Critique of Teleological Judgment, London, 1892.
LEIBNIZ, G.: *Monadology*, etc., translated by R. Latta, Oxford, 1898.
Refutation of Spinoza, Owen's translation, Edinburgh, 1855.

LOCKE, J.: *Essay on the Human Understanding.* (Abridged version of A. S. Pringle Pattison.)
LOCY, W. A.: *Biology and Its Makers.*
LOSSKY, N. O.: *The World as an Organic Whole,* London, 1928.
LOTZE, H.: *Metaphysic,* English translation by B. Bosanquet, Oxford, 1887.
LOVEJOY, A. O.: *The Revolt Against Dualism,* 1930.
LUCRETIUS, CARUS: *On the Nature of Things,* H. A. J. Munro's translation.
MACH, E.: *The Science of Mechanics,* New York, 1893.
McINTYRE, J. L.: *Giordano Bruno,* London, 1903.
MASSON, I. O.: *Three Cnturies of Chemistry,* London, 1925.
MAXWELL, J. C.: *Matter and Motion,* Edinburgh, 1920.
MERZ, T.: *History of European Thought in the Nineteenth Century,* 4 vols., London 1903–.
METZ, A.: *Une Nouvelle Philosophie des Sciences—Le Causalisme de Monsieur Meyerson,* Paris.
MEYER, E. VON: *History of Chemistry,* 2nd ed., London, 1891.
MEYERSON, E.: *Identité et Réalité,* Loewenberg's English translation, *Identity and Reality,* London, 1930.
MILL, J. S.: *System of Logic,* Books III and IV, 8th or subsequent edition, 1874, etc.
MORGAN, C. LLOYD, *Emergent Evolution,* London, 1923.
NEWTON, I.: *Opticks,* 4th ed., London, 1730. Reprint, 1933.
PEARSON, K.: *The Grammar of Science,* 2nd ed., London, 1900.
PLANCK, M.: *The Universe in the Light of Modern Physics,* London, 1931.
Where is Science Going? London, 1933.
PLATO: *Theaetetus,* translated by Jowett, Oxford, 1892.
Timaeus, translated by A. E. Taylor, Oxford, 1928.
POINCARÉ, H.: *Science and Hypothesis,* London, 1903.
POLLOCK, SIR F.: *Spinoza, His Life and Philosophy,* London, 1880, etc.
PRICE, H. H.: *Perception,* London, 1932.
PROUT, W., STAS, and MARIGNAC: *Papers on Atomic Weights* (Alembic Club Reprint, No. 20).
ROBIN, LÉON: *Greek Thought and the Origin of the Scientific Spirit,* London, 1928.
ROMANES, G.: *Mind and Motion* and *Monism,* London, 1895.
ROTH, L.: *Spinoza, Descartes, and Maimonides,* Oxford, 1924.
Spinoza (Leaders of Philosophy Series), London, 1929.
RUSSELL (B. A. W.), LORD: *An Outline of Philosophy,* London, 1927.
The Analysis of Matter, London, 1927.
The Scientific Outlook, London, 1931.

SCHWEGLER, A.: *Handbook of the History of Philosophy*, translated by J. H. Stirling, Edinburgh, 1877.

SETH, A.: *Hegelianism and Personality*, London, 1887.

SMUTS, J. C.: *Holism and Evolution*, London, 1926.

SPINOZA, B.: *Short Treatise*, translated and annotated by A. Wolf, London, 1910.

Ethics, translated by Hale White and Amelia Stirling, Oxford, 1910.

Correspondence, translated and annotated by A. Wolf, London, 1928.

De Intellectus Emendatione, translated by White and Stirling, London, 1899.

THOMSON, G. P.: *The Atom*, London, 1930.

THOMSON, J. J.: *Electricity and Matter*, London, 1904.

THORPE, T. E.: *History of Chemistry*, London, 1909, 1910.

TYNDALL, J.: *The Floating Matter of the Air*, London, 1881.

UEBERWEG, F.: *History of Philosophy*, 2 vols., New York, 1909.

VALLERY-RADOT, R.: *La Vie de Pasteur*, English translation, London, 1928.

WARD, J.: *A Study of Kant*, Cambridge, 1922.

Kant (Henriette Hertz Lecture), London.

WESTAWAY, F. W.: *Scientific Method*, 3rd ed., London, 1924.

WHETHAM, W. C. D.: *A History of Science*, Cambridge, 1930.

WHEWELL, W.: *History of Inductive Sciences*, 3 vols., 3rd ed., London, 1847.

WHITE, J. H.: *The Phlogiston Theory*, London, 1933.

WHITEHEAD, A. N.: *Introduction to Mathematics*, London, 1911.

The Function of Reason, Oxford, 1930.

Enquiry Concerning the Principles of Natural Knowledge, Cambridge, 1925.

The Concept of Nature, Cambridge, 1919.

The Principle of Relativity, London, 1922.

The Aims of Education, London, 1929.

Process and Reality, Cambridge, 1929.

Science and the Modern World, Cambridge, 1926.

Adventures of Ideas, Cambridge, 1933.

WHITTAKER, E. T.: *History of the Theories of Aether and Electricity*, Cambridge.

WINDELBAND, W.: *History of Philosophy*, New York, 1901.

WOLF, A.: *A History of Science, Technology, and Philosophy in the Sixteenth and Seventeenth Centuries*, 1934.

Encyclopædia Britannica (14th ed.), articles "Descartes," "Monism," "Ontology," "Spinoza."

Proceedings of the Aristotelian Society, 1927, "Spinoza's Conception of the Attributes of Substance."

WOLF, A. (*continued*):

Spinoza's Short Treatise (1910) and *The Correspondence of Spinoza* (1928)—Introductions and Commentaries.

Essentials of Scientific Method, 2nd ed., London, 1928.

WOODGER, J. H.: *Biological Principles*, London, 1929.

ZITTEL, K. VON: *A History of Geology and Palaeontology*, London, 1901.

INDEX OF PROPER NAMES

The references printed in heavy type indicate the pages on which the thought of the author in question receives systematic treatment.

SUBJECT INDEX